BRITISH MUSEUM (NATURAL HISTORY)

THE

JOHN MURRAY EXPEDITION 1933–34

SCIENTIFIC REPORTS

VOLUME IV, No. 9

ASTEROIDEA

BY

T. T. MACAN, B.A.

WITH TWELVE TEXT-FIGURES AND SIX PLATES

LONDON:
PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM
SOLD BY
B. Quaritch, Ltd., 11 Grafton Street, New Bond Street, London, W. 1; Dulau & Co., Ltd., 29 Dover Street, London, W. 1; Oxford University Press, Warwick Square, London, E.C. 4;
H.M. Stationery Office, London, S.W. 1
AND AT
The British Museum (Natural History), Cromwell Road, London, S.W. 7
1938

Price Ten Shillings

[*Issued 26th March,* 1938]

DESIGNED AND PRINTED
BY
ADLARD & SON, LTD.
21, HART STREET, W.C.
AT
BARTHOLOMEW PRESS
DORKING

Made and printed in Great Britain

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CONTENTS.

INTRODUCTION

The collection consists of 1160 specimens, of which 101 are small forms which it has not been possible to name. The remaining 1059 fall into 36 genera, of which one is believed to be new, and 53 species and subspecies, of which 18 are believed to be new. The majority of the previously known species have been described by one of three authors : Alcock (1893) and Koehler (1909), both of whom have reported on the collections made by the R.I.M.S. " Investigator ", and Fisher (1919), whose report on ' The Starfishes of Philippine Seas and Adjacent Waters ' is particularly valuable. The arrangement and classification put forward by Fisher (1911 *et seq.*) has been followed in the present report.

The colours of a certain number of specimens were matched with those given in ' Color Standards and Color Nomenclature ' by Ridgway (1912), as soon as possible after capture. When mentioned in the text, colours refer to this work unless the contrary is stated.

Details believed to be of systematic importance are illustrated in the text-figures, which are by the author. Each has been drawn under a *camera lucida*, but is presented somewhat diagrammatically. Spines, which in life stand erect, are usually shown lying in the same plane as the plate that bears them. For the plates I am greatly indebted to Mr. J. Henderson of the Zoological Laboratory, Cambridge.

A glossary of terms used in starfish nomenclature is given by Fisher (1906, p. 1118). The following abbreviations are used in this paper :

Abact. . .	abactinal.
SMP. . .	supero-marginal plate.
IMP. . .	infero-marginal plate.
TP. . .	terminal plate.
Act. int. .	actinal intermediate (or interradial).
Adamb. . .	adambulacral.
Adamb. Act. .	actinal surface of adambulacral plate.
Adamb. Fur. .	furrow spines.

I would like to take this opportunity of extending my sincerest thanks to Dr. Baini Prashad, Superintendent and Honorary Director of the Zoological Survey of India, who very kindly sent to Cambridge for comparison some types and other material from the collections under his care ; and to Mr. D. Dilwyn John, who has devoted much time and trouble to the correction and revision of the manuscript.

LIST OF SPECIES COLLECTED BY THE EXPEDITION

Species.	Stations at which obtained.	Total number obtained.	Depth in metres.	Locality.
Eremicaster tenebrarius (Fisher)	171	24	3840–3872	African coast.
Hyphalaster tara Alcock & Wood-Mason	171	15	3840–3872	,, ,,
H. giganteus sp. n.	171	1	3840–3872	,, ,,
Pectinidiscus annæ Ludwig	104, 106, 110	41	207–384	Zanzibar.
Astropecten polyacanthus Müller & Troschel	27, 146	106	37–91	Gulf of Aden, Maldives.
A. griegi Koehler	143, 145	13	494–797	,,
A. pusillulus Fisher	153	2	256–293	,,
A. monacanthus Sladen	80	3	16–22	Arabian Sea.
Persephonaster cingulatus (Fisher)	118, 185	2	1789–2000	Zanzibar, Gulf of Aden.
P. sewelli sp. n.	105, 110, 115, 123	9	238–658	Zanzibar.
P. gracilis (Sladen)	81, 120, 171	3	2926–3872	Arabian Sea, Zanzibar, African coast.
Dipsacaster farquharsoni sp. n.	157	1	229	Maldives.
Luidia prionota Fisher	A	2	65–68	Gulf of Suez.
L. avicularia Fisher	27	1	37–91	Gulf of Aden.
Pectinaster agassizii (Ludwig)	185	2	2000	,, ,,
P. agassizii granuliferus subsp. n.	26	3	2312	,, ,,
Benthopecten heteracanthus sp. n.	26	1	2312	,, ,,
Pseudarchaster mozaicus Alcock & Wood-Mason	108, 115, 122	4	640–786	Zanzibar.
P. diversigranulatus sp. n.	26, 59	3	1948–2312	Gulf of Aden, Arabian Sea.
Paragonaster stenostichus Fisher	105, 110	2	238–384	Zanzibar.
P. ctenipes breviradiatus subsp. n.	105, 106,	63	183–293	,,
	153	1	256–293	Maldives.
Rosaster cassidatus sp. n.	153, 157	58	229–293	,,
Mediaster ornatus Fisher	159	1	914–1463	,,
M. murrayi sp. n.	107, 109, 123	57	256–640	Zanzibar.

Species.	Stations at which obtained.	Total number obtained.	Depth in metres.	Locality.
Nymphaster moebii (Studer)	105, 108, 109, 110, 115, 122	55	238–786	Zanzibar.
	143, 145	11	494–797	Maldives.
	184	6	1270	Gulf of Aden.
Eugoniaster ephemeralis sp. n.	115	1	640–658	Zanzibar.
Lithosoma ochlerotatus sp. n.	105	1	280	,,
Astroceramus cadessus sp. n.	157	2	229	Maldives.
Milteliphaster wood-masoni Alcock	157	2	229	,,
Mabahissaster zengi gen. et sp. n.	106	1	183–194	Zanzibar.
Stellaster equestris (Retzius)	72	16	73	Arabian Sea.
Stellasteropsis colubrinus sp. n.	24, 27, 45, 53	30	13·5–200	Gulf of Aden, Arabian Sea.
S. tuberculiferus sp. n.	45	1	38	,, ,,
Monachaster umbonatus sp. n.	A	1	65–68	Gulf of Suez.
Anthenoides marleyi Mortensen	106	9	183–194	Zanzibar.
A. cristatus (Sladen)	194	495	220	Gulf of Aden.
Oreaster hiulcus Müller & Troschel	53	2	13·5	Arabian Sea.
Nardoa faouzii sp. n.	53	1	13·5	,, ,,
Narcissia mohamedi sp. n.	24, 157	2	73–229	Gulf of Aden, Maldives.
Ophidiaster purpureus Perrier	157	1	229	,,
Linckia multifora (Lamarck)	MB I	3	26–29	Red Sea.
Paranepanthia brachiata (Koehler)	24, 43, 45, 70	9	38–200	Gulf of Aden, Arabian Sea.
Henricia sp.	24	5	73–200	Gulf of Aden,
Henricia sp.	105	5	238–293	Zanzibar.
Dictyaster sp.	54	1	1046	Arabian Sea.
Acanthaster mauritiensis de Loriol	53	1	13·5	,, ,,
Pteraster obesus H. L. Clark	157, 177	4	229–366	Maldives, Gulf of Aden.
Retaster sp.	27	1	37–91	,, ,,
Hymenaster alcocki Koehler	118	1	1789	Zanzibar.
Zoroaster alfredi Alcock	81	1	3351	Arabian Sea.
Z. angulatus Alcock	159	2	914–1463	Maldives.
Cnemidaster squameus (Alcock)	185	2	2001	Gulf of Aden.
Sclerasterias mazophorus (Alcock)	35, 194	19	220–549	,, ,,
Odinia austini Koehler	152	1	609–915	Maldives.
Brisinga trachydisca Fisher	108, 115, 124	10	640–914	Zanzibar.
B. gunnii Alcock	34	1	1022	Gulf of Aden.
Freyellaster spatulifer Fisher	118	2	1789	Zanzibar.

SYSTEMATIC ACCOUNT

Order PHANEROZONIA.

Family PORCELLANASTERIDÆ.

Sub-family PORCELLANASTERINÆ.

Genus *Eremicaster* Fisher.

The following are the previous records for species of this genus; all are from the Pacific Ocean:

Species. (Synonyms in brackets.)	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
tenebrarius (Fisher)	Fisher, 1911	51	3	S. Alaska to Galapagos Is.	3867–4129 m.	Grey mud; grey ooze.
	Clark, 1913	1	1	W. coast of California	3217 m.	..
	„ 1920	24	5	Eastern tropical Pacific	3609–5121 m.	Various.
(*waltharii* Ludwig)	Ludwig, 1905	30	8	Gulf of Panama to Galapagos Is.	2418–4082 m.	Green mud; dark green sand; globigerina ooze.
pacificus (Ludwig) .	„ 1905	21	7	Ditto.	2070–3436 m.	Green mud; globigerina ooze.
	Fisher, 1911	6	3	Bering Sea, Alaska	1546–3187 m.	Grey ooze; green mud; brown ooze.
	Clark, 1913	11	3	W. coast of California	1586–1992 m.	..
	„ 1920	2	2	Eastern tropical Pacific	3609–4023 m.	Light grey and brown globigerina ooze; fine grey mud.
crassus (Sladen) .	Sladen, 1889	..	1	Mid-ocean, South Pacific	4267 m.	Red clay.
gracilis (Sladen) .	„ 1889	..	1	Off Chili	4067 m.	Blue mud.
vicinus Ludwig .	Clark, 1920	46	2	Off Peru	5121–5776 m.	Fine dark brown mud.

Eremicaster tenebrarius (Fisher).

Porcellanaster (*Eremicaster*) *tenebrarius*, Fisher, 1905, p. 293.
Porcellanaster waltharii, Ludwig, 1905, p. 92, pl. v, figs. 26 and 27.
Eremicaster tenebrarius, Fisher, 1911, p. 24, pl. i, figs. 1 to 4, pl. ii, fig. 4, pl. liii, figs. 4 and 4*a*.

OCCURRENCE:

St. 171, SW slope of the Carlsberg Ridge, 3840–3872 m.; 24 specimens.

REMARKS.—The specimens agree closely with the description of the American forms.

In all the larger examples each supero-marginal plate is armed with a spine equal in height to the plate itself (about 2·25 mm.), and two of the specimens have a second shorter spine on the third and fourth plates of each arm. The terminal plate bears five spines, a pair on the actinal edge of the outer wall directed outwards, a median spine above them, and proximally another pair which appear to continue the series of the supero-marginal spines. These two latter spines are barely 1 mm. long ; the other three are equal in size to those of the supero-marginal plates. Segmental papillæ extend about a third of the way down the arm before becoming spiniform. No specimen has more than one true adambulacral spine. The specimens range in size from R 6 mm. to R 30 mm., and the table below shows some of the features which change as the animal grows :

R, mm.	r, mm.	R/r.	Number of SMPs.	Number of SMPs unarmed.	Number of spines on TP.	Number of rows of papillæ per cribriform organ.	
						Median organ.	Outer organ.
6	3	2·0	4	All	3	6	2
6	3	2·0	5	,,	3	8	0
7	3	2·3	3	,,	3	8	0
7	3	2·3	5	,,	3	8	0
7	3	2·3	5	,,	3	8	0
7	3	2·3	5	,,	3	8	0
7	3	2·3	5	,,	3	8	0
7	3	2·3	5	,,	3	8	0
8	4	2·0	4	None	3	6	2
9	4	2·2	5	,,	3	10	2
10	4	2·5	5	Interradials	3	8	2
10	4	2·5	5	All	3	8	4
10	5	2·0	5	,,	3	8	2
11	5	2·2	5	Interradials	3	8	2
15	7	2·1	7	None	3	14	6
15	6	2·5	5	,,	5	8	4
16	7	2·3	6	Interradials	3	14	6
16	7	2·3	6	None	3	16	8
20	8	2·5	7	,,	5	12	6
22	8	2·7	8	,,	5	10	6
23	10	2·3	9	,,	5	14	10
28	11	2·5	8	,,	5	12	6
33	12	2·8	12	,,	5	16	10
30	10	3·0	11	,,	5	14	10

(i) The R/r ratio, though variable owing to the distortion of the specimens, shows a definite increase with growth. (ii) The smallest forms have no supero-marginal spines. They tend to appear first on the plates of the ray, and then on every plate. (iii) The smaller specimens have three terminal spines only ; the inner pair do not appear till later. (iv) The number of rows of papillæ forming a cribriform organ increases as the animal grows, and the two outer organs do not usually appear till the specimen has reached R 8 mm.

The young forms, which possess only a single cribriform organ, are indistinguishable from species of *Porcellanaster*, and are very different from the adult forms with three cribriform organs and supero-marginal spines. Nevertheless I believe that the trends shown in the table are sufficiently continuous to justify the inclusion of all the examples in one species.

Genus *Hyphalaster* Sladen.

Twelve species have up to the present time been ascribed to this genus, but Ludwig (1907) considers *H. valdiviæ* Chun to be synonymous with *Thoracaster cylindratus* Sladen, and *H. antonii* Perrier to be synonymous with *H. parfaiti* Perrier. Lieberkind (1932, 1935) adds *H. gracilis* Koehler and *H. fortis* Koehler to the list of synonyms of *H. parfaiti*, so that the number of species is thus reduced to eight. Their distribution is shown in the table below :

Ocean.	Species. (Synonyms in brackets.)	Number caught.	Number of stations.	Reference.	Locality.	Depth.	Bottom.
Pacific .	*diadematus* Sladen .	..	1	Sladen, 1889	W. of S. America	3800 m.	Blue mud.
	hyalinus Sladen . .	..	1	,, ,,	Mid-Pacific	5000 m.	Radiolarian ooze.
	inermis Sladen . .	..	1	,, ,,	S. of Japan	3000 m.	Blue mud.
	moseri Ludwig . .	2	1	Ludwig, 1905	,, ,,	4505 m.	Globigerina ooze.
Southern .	*planus* Sladen . .	..	1	Sladen, 1889	..	3500 m.	Diatom ooze.
	scotiæ Koehler . .	..	..	Koehler, 1907	..	2538 m.	..
Indian .	*tara* Alcock & Wood-Mason	..	..	Alcock and Wood-Mason, 1891	Bay of Bengal	3195–3650 m.	Globigerina ooze and pumice.
Atlantic .	*parfaiti* Perrier . .	1	1	Perrier, 1894	Gulf of Gascony	4787 m.	Grey yellow mud.
		26	2	Lieberkind, 1932	Coast of Norway	2278–2400 m.	Blue mud.
		..	2	,, 1935	S. Greenland	3051–3087 m.	..
	(*antonii* Perrier) .	1	1	Perrier, 1894	Azores	2995 m.	Soft white mud.
		2	2	Koehler, 1909*a*	Azores, Cape Verde Is.	3800–5430 m.	Sand and mud.
	(*gracilis* Koehler) .	3	1	,, ,,	Coast of Spain	5413 m.	Globigerina ooze.
	(*fortis* Koehler) .	3	2	,, ,,	Cape Verde Is., Azores	3890 m. 4360 m.	Sand and mud. Globigerina ooze.

Hyphalaster tara Alcock & Wood-Mason.

Hyphalaster tara, Alcock & Wood-Mason, 1891, p. 434, text-fig. 11.

Occurrence :

St. 171, SW slope of the Carlsberg Ridge, 3840–3872 m. ; 15 specimens.

Distribution.—Bay of Bengal ; Indian Ocean off NE Africa.

Description.—The following description is taken from one of the seven larger specimens, the dimensions of which are : R 20–25 mm . and r 8–12 mm. R/r varies

from 2·0–2·5. It is not possible to get a more accurate figure owing to the distortion which the specimens have suffered.

The *abactinal surface* is beset with rather small, well-spaced paxillæ, each bearing three or four rounded granules. At the base of each radius there is a conspicuous patch of larger paxillæ, each of which has ten to twenty granules. The proximal end of the patch is about 2 mm. from the centre of the disk ; the patch is some 3 mm. long by 1 mm. broad, and its distal end is about 6 mm. from the point where the third pair of supero-marginals come into contact. Each patch contains eighteen to twenty-four paxillæ in three irregular rows, and there are also two rows of large paxillæ lying parallel with, but separated by two rows of small paxillæ from, the four supero-marginal plates which bound the disk.

The madreporite, which measures about 1 mm. radially by 2 mm. tangentially, lies against the supero-marginals on one of the interradii and its sulci radiate from a point on its inside edge. The cribriform organs, three to each interradius, are composed of sixteen rows of papillæ. An epiproctal cone, 1 to 2 mm. long, is present.

There are six *supero-marginal plates*, of which the distal four are in contact with their opposites down the length of the ray. The first plate is about 3 mm. long, the next four 2·5 mm. long, and the sixth 2 mm. long. All are about 2 mm. high and are gently curved. For the most part they lie horizontally and form a broad border to the paxillar area, with the infero-marginal plates just visible beneath them, but this varies considerably with the condition of distortion of the specimen and the plates may lie almost vertically. They are always set at a steeper angle on the arms. The infero-marginals lie directly below the supero-marginals, but their height is uniformly less, decreasing from 2 mm. interradially to rather less than 1 mm. at the end of the arm. They stand vertically and do not encroach on the actinal surface.

The *terminal plate* is large, about 3 mm. long by 3 mm. high, faintly carinate and armed with four fine tapering spines, hyaline at the tip and 3 mm. long. The first spine is situated on the mid-abactinal line near the proximal edge of the plate and points vertically upwards. The second spine is also median and abactinal in position and projects upwards and outwards from a point near the distal edge of the plate. A pair of spines, directed horizontally, arise from the actinal border of the end wall of the terminal plate. The surface of the supero-marginal and terminal plates is covered by a series of very fine papillæ.

The *actinal intermediate areas* are paved with regular columns of rectangular, imbricating plates, devoid of spines. There are eight columns running at right angles from the infero-marginal plates to the adambulacral and mouth plates. There are also eight rows tangentially, but the arrangement in this direction is less regular. Each of the *adambulacral plates* bears a furrow comb of five or six short flattened and bluntly triangular spines ; these are usually folded back over the actinal surface of the plate, which is devoid of any armature. The *mouth plates* bear a pair of short stout conical spines projecting into the mouth cavity, and a comb of seven or eight spines, similar to those of the adambulacral plates, projecting into the furrow.

Variation.—Among the seven larger specimens the following variations are found : (i) One example shows a remarkable elaboration of the pattern formed by the large paxillæ. A second radial patch, of twelve to fifteen large paxillæ in two irregular rows, lies distal to the first and is separated from it by two or three rows of small paxillæ. About a

millimetre on either side of this second patch, and a little nearer the centre, there is a group of four to twelve large paxillæ. (ii) There is variation in the size of the large paxillæ, and this is particularly marked in the rows near the supero-marginal plates, for the component paxillæ of these are in some examples three to four times, in others barely twice. the size of their neighbours. (iii) One specimen has five small granules on the actinal surface of each mouth plate. In the rest the mouth plates have no actinal armature.

Young Forms.—Eight specimens have a major radius of between 6 and 12 mm. All that are not too badly damaged show a small patch of enlarged paxillæ on each radius. Other features are: R/r about 2·0; supero-marginal plates three to four; four to six furrow spines; three spines only on the terminal plate, the proximal of the two median spines being absent.

Hyphalaster giganteus sp. n. (Pl. I, figs. 3 and 7.)

Occurrence:

St. 171, SW slope of Carlsberg Ridge, 3840–3872 m.; 1 specimen.

Diagnosis.—Close to *Hyphalaster parfaiti* Perrier, differing mainly in lacking spinelets on the actinal intermediate plates. Disk large, inflated; arms long, thin and tapering; interbrachial arcs widely rounded; cribriform organs nine. Abactinal surface beset with uniform paxillæ, each with one or two central spinelets surrounded by a circle of seven to nine similar spinelets. Supero-marginals twenty-six, the distal twenty-one in contact abactinally. Infero-marginals corresponding to supero-marginals, except in middle of arm, where they are a little longer. Actinal intermediate plates rectangular, imbricating; arranged in radial and tangential columns; devoid of granules or spines. Adambulacral plates with four or five conical furrow spines and two fine acicular spinelets on the actinal surface. Mouth plates armed each with a strong spine projecting into mouth cavity, and six or seven furrow spines similar to those of adambulacral plates; actinal surface with five small hemispherical granules.

Description.—R 88 mm., r 24 mm., R/r 3·6. The single specimen is in poor condition, for it has only one complete arm, which was broken, but still attached, when the animal was brought up. The *abactinal surface* is much inflated, apparently by a large collection of mud in the stomach. It is covered by uniform close-set paxillæ, on each of which there is a whorl of seven to nine spinelets surrounding one, or occasionally two, similar spinelets, which are roughly twice as high as broad, slightly tapering and rounded at the tip. There is no epiproctal cone. The madreporite, lying against the supero-marginal plates on an interradius, measures 4·5 mm. tangentially and 4 mm. radially. Its furrows radiate from a point about 1·5 mm. from the inside edge.

The *supero-marginal plates* number twenty-six, and of these the distal twenty-one are in contact with the corresponding plate of the opposite side of the ray. The plates are longer than high in the interradius, square at the base of the arms, and thence higher than long, as is shown by the following measurements:

	Plate No. 1.	11.	20.	26.
Length . . .	5 .	3·5 .	2·5 .	1·25 mm.
Height . . .	4 .	3·5 .	3 .	2 ,,

Seen in section the plates slope inwards, are somewhat curved, and meet at a point so that the arm has the shape of a Gothic arch. The plates bordering the disk are similar in position and shape, but when seen from the side they are slightly tumid whereas along the arm the plates are quite flat.

In the middle of the single arm the *infero-marginals* are a little longer than the supero-marginals, but elsewhere they correspond with them except at the base of one of the broken arms, where injury is, perhaps, responsible for the irregularity. The plates are rectangular and do not encroach on the actinal surface. Their dimensions are :

	Plate No.			
	1.	10.	20.	26.
Length	5	4	3	1·75 mm.
Height	3	3·5	2	1 ,,

Both sets of plates are covered with very small papillæ, which to the naked eye give a "matt" effect. On the abactinal surface a strip of brownish pigment extends down the centre of each arm.

In two of the interradii there are nine *cribriform organs*, each extending over both supero- and infero-marginal plates. The outermost organ is made up of sixteen, the innermost of twenty rows of slightly elongate papillæ. The interradius in which the madreporite is lodged has but eight cribriform organs and these occur only between the infero-marginal plates ; between the supero-marginals only a few papillæ are to be seen, mostly lying near the upper edge of the plate ; the remainder have probably been scraped off. One of the arms has evidently been injured and regeneration has led to irregularity in the arrangement of the plates, for the infero-marginals no longer correspond to the supero-marginals. As a result two interradii have seven complete cribriform organs and one half-organ between the supero-marginals. In one case this lies isolated ; in the other two supero-marginal portions converge on one infero-marginal portion and form a Y-shaped organ.

The *actinal intermediate areas* extend to the eighth or ninth infero-marginal and the component plates lie in regular radial columns, of which the central column contains ten to twelve plates, and less regular tangential rows. As the outer border of the area is approached the plates show a decrease in size. Their surface is quite smooth.

The *adambulacral plates* are mostly badly damaged. There are four or five conical furrow spines, those in the centre nearly 2 mm. in length, those outside commonly about half this size. Near the outer border of the actinal surface two fine pointed spinelets, about 0·5 mm. long, are found.

Each *mouth plate* bears a robust spine directed into the mouth cavity and a furrow series of seven spines similar to those of the adambulacral plates. On the actinal surface five small hemispherical granules form two series, one parallel with the furrow and another parallel with the suture between the adjacent plates.

Affinities.—Two other species of *Hyphalaster* which possess nine cribriform organs have been described, and the table below shows the main differences between them and *H. giganteus* :

Species.	R.	R/r.	Number of SMPs.	Act. int. plates.
giganteus . .	88 mm. .	3·6 .	26 .	Bare.
parfaiti . . .	55 ,, .	3·0 .	16 .	Spiny.
moseri . . .	32·5 ,, .	2·5 .	11 .	,,

The greater R/r ratio and more numerous supero-marginal plates of *giganteus* are of doubtful significance in view of its greater size, but, on account of the complete absence of spines or granules on the actinal intermediate plates. it would not be justifiable to regard the present example as identical with either *H. parfaiti* or *H. moseri*. There is a possibility that it belongs to a known species, but is unrecognizable owing to the discrepancy in size between it and the described type, but there are no grounds for this view and the course open to least objection is the creation of a new species.

Sub-family Ctenodiscinæ.

Genus *Pectinidiscus* Ludwig.

Pectinidiscus annæ Ludwig.

Pectinidiscus annæ, Ludwig, 1907, p. 312; Lieberkind, 1932, p. 293, pl ii, figs. 3–8, pl. v, figs. 4–13, pl. vii, fig. 3.

Occurrence and Distribution.—The genus contains two species, *P. sibogæ* Döderlein, from the Malay Archipelago, and *P. annæ* Ludwig, of which all the known records are shown in the table below:

Expedition.	Station.	Number caught.	Locality.	Depth.	Bottom.
" Valdivia "	242	3	Off Dar-es-Salaam	404 m.	Green mud.
,,	243	2	,,	400 m.	. .
,,	245	50	Zanzibar channel	463 m.	Globigerina ooze, blue clay.
" Mabahiss "	104	1	,,	207 m.	Grey green mud, sand and shells.
,,	106	38	,,	183–194 m.	Green mud.
,,	110	2	,,	347–348 m.	Grey green mud, sand and shells.

Remarks.—The table on p. 334 throws some light on some of the changes which accompany growth.

The changes which accompany growth are: (i) The R/r ratio increases. (ii) The number of supero-marginal plates bearing spines becomes proportionately greater. The variation in the absolute number of spines is noted by Lieberkind. (iii) It is characteristic

of adults to have smaller paxillæ on the epiproctal funnel and alongside the superomarginals. In small specimens in which R is less than 14 mm. only the paxillæ on the epiproctal funnel are noticeably smaller than those of the rest of the disk. (iv) The smaller specimens commonly have four instead of five furrow spines.

The paxillæ of the smallest specimens examined are surmounted by a crown of six to eight granules about a single one. This condition persists unchanged up to the largest, with the exception of the specimen with R 24 mm. from St. 106, in which some of the paxillæ bear as many as twelve peripheral granules.

St.	R, mm.	r, mm	R/r.	Number of SMPs.	Number of SMPs armed.
106	6	2·75	2·1	6	3
104	6	2·5	2·4	7	0
106	7	3	2·3	7	0
,,	7	3	2·3	7	0
,,	7	3	2·3	7	2
,,	7	3	2·3	7	2
,,	7	3	2·3	7	3
,,	7·5	3·5	2·1	7	3
,,	7·5	3·5	2·1	7	3
,,	8	4	2	7	2
,,	8	3·5	2·3	7	3
,,	8·5	4	2·1	7	4
,,	8·5	3·5	2·4	7	4
,,	9	3·5	2·5	7	2
,,	9	3·5	2·5	7	3
,,	9	3·5	2·5	7	4
,,	9	3·5	2·5	7	4
,,	9	3·5	2·5	7	4
,,	9	3·5	2·5	7	3
,,	9·5	3·5	2·7	7	4
,,	9·5	4	2·4	7	5
,,	10	4	2·5	7	2
,,	10	4	2·5	8	5
,,	11	4·5	2·4	7	5
,,	11	4·5	2·4	8	3
,,	11	4	2·75	7	5
,,	11·5	4·5	2·8	11	3
,,	13·5	5	2·7	9	6
,,	13·5	5·5	2·4	10	6
,,	14	5·5	2·5	9	6
,,	14	5	2·8	11	6
,,	14	5·5	2·5	10	8
110	17	6	3	11	9
106	24	8	3	14	10
110	33	11	3	16	13

Family Astropectinidæ.

Genus *Astropecten* Gray.

Döderlein (1917) has monographed this genus.

Astropecten polyacanthus Müller & Troschel.

Astropecten polyacanthus, Müller & Troschel, 1842, p. 69; Döderlein, 1917, p. 134, pl. iv, figs. 4, 5, pl. xii, figs. 4, 5.

Occurrence:

St. 27, Gulf of Aden, 37–91 m., sand and shingle; 1 specimen.

St. 146, Maldives, 37 m., soft cream mud; 105 specimens.

Distribution.—Widely distributed throughout the tropical Indo-Pacific region.

Astropecten griegi Koehler.

Astropecten griegi, Koehler, 1909, p. 26, pl. vii, fig. 4, pl. x, fig. 6; Döderlein, 1917, p. 117, pl. i, fig. 6, pl. x, figs. 1, 1*a*.

Occurrence:

St. 143, Maldives, 797 m., green sand; 5 specimens.

St. 145, Kardiva Channel. Maldives, 494 m., green mud and sand; 8 specimens.

Distribution.—Laccadive Sea and Andaman Sea, 236–850 m.; Maldives.

Remarks.—The dimensions of twelve of the thirteen specimens are as follows:

	Specimen.												
	Station 143.				Station 145.								
	1.	2.	3.	4.	1.	2.	3.	4.	5.	6.	7.	8.	
R	60	48	..	..	50	48	45	42	40	25	..	..	mm.
r	9	8	7	7	8	8	7	8	8	5	8	5	,,
R/r	6·6	6·0	..	..	6·2	6·0	6·3	5·2	5·0	5·0	..	..	

Astropecten pusillulus Fisher.

Astropecten pusillulus, Fisher, 1906, p. 1008, pl. i, fig. 3, pl. ii, figs. 4, 4*a*, 4*b*.

Occurrence:

St. 153, Maldives, 256–293 m.; 1 whole specimen and 1 disk.

Distribution.—Hawaiian Islands; Maldives. Fisher records 650 specimens from 267–683 m. at the former locality.

Remarks.—R 55 mm., r 11 mm., R/r 5·0; breadth of ray at base 9 mm., number of SMPs, 35. The single entire specimen is in good condition, and though larger, agrees

closely with the description of the Hawaiian forms. While the majority of the paxillæ resemble those of the type in having one central and six to eight peripheral granules, a few of the largest at the base of the ray have as many as twelve peripheral and three central. The infero-marginals are armed with two spines, the outer 3 mm. and the inner 2·75 mm. long. A third much smaller spine is present on the proximal plates. There are three small spines on the first plate. Pedicellariæ occur on the actinal intermediate and on many adambulacral plates.

Colour.—Paxillar area, light greyish olive; supero-marginals white, with a continuous longitudinal line along the outer edge and a series of transverse stripes across the abactinal surface scarlet; infero-marginals and actinal surface white; tube feet avellanous.

Astropecten monacanthus Sladen.

Astropecten monacanthus, Sladen, 1889, p. 216, pl. xxxvii, figs. 10–12, pl. xxxiii, figs. 7, 8; Döderlein, 1917, p. 150, pl. xiv, figs. 5, 5*b*, pl. xvii, fig. 9.

Occurrence:

St. 80, off Ras al Hadd at the eastern point of Arabia, 16–22 m., coarse sand and shells; 3 specimens.

Distribution.—Widely distributed in the tropical Indo-Pacific region.

Remarks.—The dimensions of the three specimens are:

	Specimen.		
	1.	2.	3.
R	53	44	41 mm.
r	14	13·5	12 ,,
R/r	3·8	3·2	3·4

Genus *Persephonaster* Alcock & Wood-Mason.

A synopsis of the known species of this genus is given by Döderlein (1921, p. 26).

Persephonaster cingulatus (Fisher).

Psilasteropsis cingulata, Fisher, 1906, p. 1023, pl. iii, figs. 2, 2*a–b*, pl. vii, figs. 1, 2, 3, pl. viii, fig. 2.
Persephonaster cingulatus, Fisher, 1919, p. 111.

Occurrence:

St. 185, Gulf of Aden, 2000 m., green mud; 1 specimen.

St. 118, Zanzibar, 1789 m., globigerina ooze; 1 specimen.

Distribution.—Previously known only from the Hawaiian Islands.

Remarks.—The dimensions of these two specimens are as follows:

Gulf of Aden specimen: R 125 mm., r 24 mm., R/r 5·2.

Zanzibar specimen: R 92 mm., r 19 mm., R/r 4·9.

The following are measurements of the larger specimen :

	Plate No.					
	2.	6.	10.	15.	20.	25.
Breadth of arm	24	21	17	13	10	6·5 mm.
,, of paxillar area	19	11	8	6	4	3 ,,
Number of paxillæ	23	17	13	9	7	c.7

The outer border of each supero-marginal is somewhat pointed and the distance between the points is taken as the breadth of the arm. The number of paxillæ is the number in the chevron running across the ray from one marginal plate to the other.

Abactinal surface.—Except in the very centre and alongside the marginal plates, where they are a little smaller, the paxillæ of the disk are uniform in size and on their circular tops stand about thirty short round-tipped spinelets. A similar number surmount the paxillæ at the base of the ray ; in this region the tops of the paxillæ are twice as long as broad, but as they decrease in size along the ray their length may reach three times their breadth, for near the tip of the ray there are some with two parallel rows of six granules. The paxillæ of the arms lie in chevrons, each arching in a gentle curve across the arms from supero-marginal to supero-marginal, the convexity being directed towards the centre.

There are thirty-eight *supero-marginals.* The first four plates are narrow but the abactinal face of the next few encroaches more and more on to the paxillar area. The height of the first plate is a little over twice its length, but on successive plates the height decreases and the length increases slightly, and from the tenth plate to the tip of the ray the two dimensions are equal. Each plate is strongly and acutely tumid, the median ridge lying in the centre of the first few plates but coming to lie nearer the distal margin of the remainder. The plates are covered with fine short capillary spinelets, but as these mount the ridge they become larger and much flatter, till they are little more than bosses. The actual summit of the ridge is occupied by a row of about ten of these flat bosses, larger than all the rest and equal in diameter to the base of one of the infero-marginal spines.

The *infero-marginals* correspond with the supero-marginals but their height is a little less, and they encroach more on to the actinal surface than do the supero-marginals on to the abactinal. The actinal surface is slightly convex, while the lateral face is raised into a ridge running obliquely from a point below the ridge of the supero-marginal above to the distal edge of the plate. The ridge bears four fine tapering appressed pointed spines. The uppermost is usually only about a quarter the length of the remainder, which are 4 to 5 mm. long. Either all three are of the same length, or the lowest is a little shorter than the other two. An extra spine stands on the lower proximal border of the first two plates. The rest of the plate is covered with pointed squamules which become smaller towards the edge.

The *actinal intermediate areas* are small, and comprise four chevrons of plates. Of the twenty plates in the innermost chevron, six extend in a contiguous series to the fourth infero-marginal, while the rest lie isolated and attain the twelfth infero-marginal. The next chevron contains six plates reaching the third infero-marginal ; the third contains four plates reaching the second infero-marginal ; while the outermost contains three

plates, which reach only the distal border of the first infero-marginal. The plates are covered with papilliform spinelets, of which one in the centre often stands out from the rest and reaches a length of 2 mm.

The *adambulacral plates* have a strongly angular margin, the proximal facet being the shorter, especially on the first three plates. There are nine to eleven closely crowded, slightly flattened, round-tipped subequal furrow spines, 2 mm. or a little more in length, Actinally stand twelve to fifteen spines irregularly arranged, similar to the furrow spines but smaller, those in the centre of the plate about half, those near the outer border about a quarter as long.

The *mouth plates* bear a furrow series of nine or ten closely crowded spines, which are smaller than those of the adambulacral plates. The inner angle of each plate is occupied by an enlarged spine, about 3 mm. long by 1 mm. broad. The spines of adjacent plates lie together and bear a striking resemblance to a cloven hoof. The strongly salient actinal surface of the plates is occupied by short spines lying in two groups. The first group consists of seven spines in two ill-marked rows parallel with the suture between the mouth plate and the first adambulacral plate. The second group consists of twelve spines in two irregular rows parallel with the suture between adjacent mouth plates. The row next the suture is made up of eight closely crowded spines, the other of four well-spaced spines.

The smaller specimen agrees with the above description except that the first four or five infero-marginal plates bear five or six spines.

Comparison with Fisher's description of *Persephonaster cingulatus* reveals some small differences ; the Hawaiian form has slightly broader supero-marginals ; eleven to thirteen, instead of nine to eleven furrow spines ; and more numerous actinal mouth spines. These differences, however, do not seem great enough to merit specific recognition.

The *colour* was not matched, but the larger specimen is recorded as being "an intense dark red with lighter marginal plates". In spirit it is brownish.

Persephonaster sewelli sp. n. (Pl. I, figs. 5 and 6 ; Text-fig. 1.)

Occurrence.—At the following stations all near Zanzibar :

St. 105, 238–293 m., green mud ; 5 specimens.

St. 110, 347–384 m., grey-green mud and sand ; 2 specimens.

St. 115, 640–658 m. ; 1 specimen.

St. 123, 256–366 m., green mud, sand and rocks ; 1 specimen.

Diagnosis.—R/r 5. Actinal surface flat, abactinal surface slightly raised. Arms long, tapering evenly to an attenuate point. Abactinal paxillæ rather small, well spaced, bearing a brush-like arrangement of some twenty-five bluntly-pointed spinelets about 0·5 mm. in length. Supero-marginals forty, forming well-marked border to paxillar area ; slightly tumid ; armed with a short robust spine, accompanied in distal half of ray by a second shorter spine ; covered with squamules centrally and several rows of capillary spinelets near distal and proximal edges. Infero-marginals with three or four fine tapering appressed spines ; first two plates with actinal spines in addition ; plates covered with squamules coarser than those of supero-marginals and two rows of capillary spinelets near adjacent edges. Actinal intermediate areas small, comprising four irregular chevrons ; plates bearing twelve to twenty spinelets ; pedicellariæ, composed of about

half the total number of spines, present on first few plates of innermost chevron, a tapering spine springing from centre of first few plates of remaining chevrons. Adambulacral plates with six furrow spines and on the actinal surface two rows of four or five more delicate spines. Mouth plates with five furrow spines, the proximal edge straight, the distal edge convex; actinally three rows of spinelets, the three innermost of the row alongside the suture between adjacent plates greatly enlarged.

Description.—The measurements of eight of the specimens are as follows :

R.	r.	R/r.	From Station—
80 mm.	16 mm.	5	105
76 ,,	15 ,,	5	105
76 ,,	15 ,,	5	110
75 ,,	15 ,,	5	105
75 ,,	15 ,,	5	110
65 ,,	13 ,,	5	105
33 ,,	8 ,,	4	105
29 ,,	7 ,,	4	123

The *abactinal surface* is beset with rather small well-spaced paxillæ, which are largest in the interradius and at the base of the ray, and become smaller in the centre, in the neighbourhood of the supero-marginals, and down the length of the arms. They stretch across the arms in lines that are almost straight but show a slight arching towards the centre of the disk. The number of paxillæ per row between successive pairs of supero-marginals is shown in the table below. The larger paxillæ are surmounted by a brush-like arrangement of about twenty-five roundly pointed spinelets, approximately 0·5 mm. in length.

	SM plate No.							
	1.	4.	8.	12.	16.	20.	24.	30.
Breadth of arm	21	16	12	10	8	6	4·5	3 mm.
,, of paxillar area	18	12	7·5	5·5	4·5	3·25	2	1·5 mm.
Number of paxillæ	..	23	15	15	11	9	5	3

The *supero-marginals* form a well-marked border to the paxillar area throughout, though they encroach more on the arms than on the disk. The first two plates are high, narrow and short, but the height of successive plates decreases while the breadth and length, which are always equal, increase up to the tenth plate.

Dimensions :

	Plate No.			
	1.	5.	10.	15.
Height	2·5	1·75	1	0·75 mm.
Length	1·5	2	2·25	2 ,,
Breadth	1·5	2	2·25	2 ,,

The plates are slightly tumid; the apex of the tumidity occupies the centre of the first two plates, but on succeeding plates approaches the distal border. On the apex, near the outer edge of each plate, there is a robust pointed spine, 1 to 1·5 mm. in length. On the outer half of the ray a smaller one may stand close beside it. The plates are covered with small, rather elongate pointed squamiform granules, of which a few round

the base of the spine are enlarged. Towards the suture between adjacent plates the squamules are replaced by several rows of fine capillary spinelets.

The *infero-marginals* form a well-defined border to the actinal surface, but, unlike the supero-marginals, they are broader than long, and they are low in the interradius and increase in height at the base of the rays. Dimensions :

	Plate No.			
	1.	5.	10.	15.
Height	1·5 .	2 .	1·5 .	1 mm.
Length	1·75 .	2 .	2 .	1·5 mm.
Breadth . . .	3 .	3 .	3 .	2 ,,

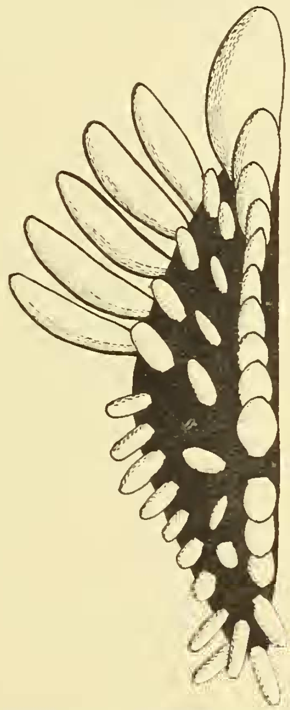
The first two plates bear three spines, 2 to 3 mm. long, on the middle of the lateral surface and, unlike all the rest of the plates, one or two shorter spines on the actinal surface. The plates of the proximal half of the ray bear near the distal border of the lateral surface four, or sometimes only three, fine tapering appressed spines, of which the two in the centre are longer and more robust. The lower of these two central spines is a trifle the longer and attains a length of 5 or 6 mm. On the plates of the distal half of the ray there are only three spines. The surface of the plates is covered with squamiform granules, which are coarser and less pointed than those of the supero-marginals. About the bases of the spines these squamules are elongated, and at the edges, near the sutures between adjacent plates, they give place to about two rows of capillary spinelets.

The *actinal intermediate areas* are small, and the plates are arranged in four rather irregular chevrons. The first chevron contains twenty-two plates, extending beyond the third infero-marginal as a series of isolated plates which reach the fifteenth infero-marginal. The next two chevrons contain respectively nine and six plates reaching the fourth and third infero-marginal. A fourth chevron consists of three plates lying parallel with the interradial suture. The plates project as irregular, round or oval bosses, on which stand a number of delicate round-tipped or pointed spinelets, measuring perhaps 1 mm. in length. On the first five plates of the innermost chevron the spines number sixteen to twenty and as many as half of them may be grouped together into a pedicellaria. On the first two or three plates of the remaining chevrons the spines number twelve to sixteen, and from their midst emerges a more robust tapering pointed spinelet 2 mm. or more in length.

The furrow margin of the first three or four *adambulacral plates* is strongly angular, the proximal facet being the shorter. The rest of the plates have an evenly rounded furrow margin. This bears six parallel slightly flattened spines, which taper at the tip to a rounded point. The two outer spines are always shorter than the rest ; the two inner spines, which reach a length of 3·25 mm., are sometimes a little longer than the spine on either side of them, sometimes of the same length. Two rows of four or five spines stand on the actinal surface of the plate. They resemble the furrow spines but are shorter and more delicate. Those of the inner row are about half as long as the furrow spines, those of the outer a little shorter than those of the inner row. One or two spines are often found between the two rows or outside the outer one.

Mouth plates (Text-fig. 1).—Over the very salient actinal surface of each plate and alongside the suture which separates it from its neighbour runs a row of fifteen spines. Distally these are small and round-tipped, centrally they are squamiform, while beyond

the middle they begin to elongate again, and the proximal three are successively larger as they near the mouth angle, where the innermost projects as a vast, bluntly pointed tooth. Parallel with this row a line of seven smaller round-tipped or pointed spines runs down the centre of the plate. The border adjacent to the first adambulacral plate is occupied by nine spines, most a little larger than those of the middle row, and the series is continued by four spines which lie on the free border of the mouthplate, immediately above the furrow spines. These latter, five in number, are lodged deep within the furrow. They are flattened, somewhat pointed, straight-sided proximally and convex distally.



TEXT-FIG. 1.—*Persephonaster sewelli* sp. n. Mouth plate × $12\frac{1}{2}$.

YOUNG FORMS.—The two young specimens, with R 29 and 33 mm., have all the characters of the larger forms, including actinal infero-marginal and actinal intermediate spines. The differentiation between the two types of granule on the marginal plates is less well marked but is still clearly to be distinguished.

AFFINITIES.—I have, through the kindness of the Indian Museum, been able to compare the present specimens with Alcock's type of *Persephonaster cœlochiles*. The arms of this species are broad at the base and remain parallel-sided for a short distance before beginning to taper. The arms of *P. sewelli* taper from the base, and their tip is more attenuate than in *P. cœlochiles*. Further this latter species has more tumid supero-marginals, and their entire surface is covered by capillary spinelets; the infero-marginals also lack any trace of squamules and their spines usually number only three; and the actinal plates lack central spinelets.

I think this species would fall into section *a*3 of Fisher's key (1919, p. 111), but the chief criterion is whether the supero-marginals are, or are not, massive, and this character is difficult to assess in the absence of specimens with which comparison can be made. Its nearest relatives would seem to be *P. habrogenys* Fisher and *P. œdiplax* Fisher. The latter species has shorter rays, no squamules on the marginal plates, no actinal spines

and pedicellariæ on the abactinal, marginal, actinal intermediate and adambulacral plates. *P. habrogenys* has longer arms, small infero-marginals with actinal spines, no spines on the actinal intermediate plates and abactinal pedicellariæ.

The species is named *sewelli* after Lt.-Col. R. B. Seymour-Sewell, leader of the expedition.

Persephonaster gracilis (Sladen).

Psilaster gracilis, Sladen, 1889, p. 230, pl. xli, figs. 5 and 6, pl. xlii, figs. 9–11.
Dytaster anacanthus, Alcock & Wood-Mason, 1891, p. 424 ; Alcock, 1893, p. 80.
Persephonaster gracilis, Fisher, 1919, p. 123.
Persephonaster anacanthus, Fisher, 1919, p. 133.

Occurrence :

St. 81, Gulf of Oman, 3351 m., grey clay ; 1 specimen.
St. 120, Zanzibar area, 2926 m., brown mud ; 1 specimen.
St. 171, Carlsberg Ridge, 3840–3872 m. ; 1 specimen.

Distribution.—Japan, 3373 m., blue mud (Sladen), Bay of Bengal, 3195 m., globigerina ooze and pumice (Alcock) ; Gulf of Oman, Carlsberg Ridge, Zanzibar.

Description.—The measurements of the specimens are : St. 81, R 92 mm., r 16 mm., R/r 5·7 ; St. 120, R 55 mm., r 10 mm., R/r 5·5 ; St. 171, R 85 mm., r 15 mm., R/r 5·6. The following description is taken from the two larger specimens. The disk is flat. The arms taper abruptly at the base and then more gradually to a blunt tip. In transverse section they are rectangular at the base, round distally. The interbrachial arcs are acutely rounded.

The largest paxillæ on the *abactinal surface* have a diameter of about 0·5 mm., and occur on the interradii and the base of the arms. On the arms the paxillæ are twice as long as broad, and lie between the supero-marginals in chevrons which show only a very slight arching towards the centre of the disk. Two or three chevrons correspond to one supero-marginal plate. Each paxilla is uniformly beset with cylindrical round-tipped or slightly clavate granules, which stand up vertically. The madreporite has a diameter of 2 mm., and lies a little nearer to the edge of the disk than to the centre.

There are forty-two *supero-marginals*, which encroach on to the abactinal surface only in the distal half of the rays. The first plate is high and short. The second and third plates show an abrupt, the remainder a gradual, decrease in height, while the length increases a little up to the tenth plate.

Dimensions :

	Plate No. 1.	5.	10.	20.	30.	
Height	4·5	3·25	3	2	1·5	mm.
Length	1·75	2	2·5	2	1·5	,,

The first ten plates are flat, the rest are rounded. Their surface is covered with a close-set nap of fine, slightly elongated granules, similar to those on the abactinal paxillae but more pointed.

The *infero-marginal plates* correspond to the supero-marginals and resemble them in size and shape, except that all encroach on to the actinal surface. The first plate bears three fine pointed spines, about 4·5 mm. long, on the centre of the lateral face. A

similar row is found on the remaining plates but it is set obliquely, the lowest spine almost on the distal border, the uppermost near the centre of the abactinal border of the plate. The granules of the infero-marginals are more robust and pointed than those of the supero-marginals, and on the actinal surface of each plate they are longer and attain a length of about 0·75 mm.

The *actinal intermediate areas* are very small. The plates lie in three fairly well-defined chevrons, without any median plates lying on the interradial line. The innermost chevron has eight plates, of which the proximal four are in contact, and the distal four lie isolated and extend to the level of the seventh infero-marginal. In the second chevron there are five plates reaching the third infero-marginal, while the outermost contains four plates which extend no further than the distal edge of the first infero-marginal. The plates are beset with robust pointed spinelets closely crowded together.

The first two or three *adambulacral plates* have a strongly angular margin, of which the proximal facet is the shorter; the rest have a uniformly rounded margin. The furrow spines number seven, of which, on the angular plates, two stand on the proximal and five on the distal facet. The spines are subequal, about 2 mm. long, stout, bluntly pointed at the tip and invested with membrane which often gives them a clubbed appearance. The actinal surface of the plate bears eight to ten irregularly arranged spines similar to the furrow spines but of half to two-thirds the size.

On the inner angle of each *mouth plate* stands a vast spine which in one specimen is shaped like a mortar trowel but which in the other is narrower and like the one figured by Sladen. Close behind are two spines side by side, similar, but barely half the size. Parallel with the suture between adjacent plates a row of nine or ten spines like those of the actinal intermediate plates runs from the proximal to the distal corner. A row of similar but slightly smaller spines lies parallel with this, and a third row runs round the free margin of the plate. Below it, deep within the furrow, lie five or six furrow spines rather shorter than those of the adambulacral plates.

Colour.—The colour of the specimen obtained at St. 171 was a uniform aster purple with the marginal spines a little darker.

Affinities.—The specimens have been compared with an example of *Dytaster anacanthus*, kindly lent by the Indian Museum, and with the type of *Psilaster gracilis* at the British Museum, and I have little doubt that they are one and the same species.

Genus *Dipsacaster* Alcock.

A list of the known species of *Dipsacaster* is given by Döderlein (1921, p. 18). There are two additions to be made to this list: *Lonchotaster magnificus* H. L. Clark (1916, p. 30, pl. vi, figs. 1 and 2: Great Australian Bight, 144–216 m.), which is referred to the genus *Dipsacaster* by Fisher (1919, p. 150), and *Dipsacaster grandissimus* Goto (1914, p. 252, pl. viii, figs. 136–139; pl. ix, figs. 140 and 141: Japan, 640 m.).

Dipsacaster farquharsoni sp. n. (Pl. I, figs. 1 and 4.)

Occurrence:

St. 157, Maldives, 229 m., coral rock; 1 specimen.

Diagnosis.—R/r 2·7. Body rather flat. Arms broad at base, tapering somewhat rapidly to a blunt point. Interbrachial arcs widely rounded. Paxillar area small; paxillæ

tabulate and arranged in chevrons; the largest with a central group of ten to fifteen pointed granules, and a radiating peripheral series of thirty to thirty-five fine slightly clavate spinelets. Supero-marginals very broad; confined to abactinal surface; beset with large flat angular granules and fine clavate spinelets at edge. Infero-marginals very broad; defining ambitus; beset with squamules, which elongate near outer edge of plate, two or three projecting as flattened blade-like spines; other edges with clavate spinelets. Actinal intermediate areas large, reaching thirteenth infero-marginal; plates with raised oval tabula on which stand thirty to forty coarse radiating clavate spinelets, of which one is often enlarged. Adambulacral plates with nine or ten spines on inner (furrow) margin, and three or four on outer and lateral margins; furrow spines fine long radiating, spines on outer margin about half size of furrow spines, spines on lateral margins decreasing in size as furrow approached; three spines in centre of actinal face.

Description.—R 60 mm., r 22 mm. The *paxillar area* is not extensive, and its breadth at the levels of successive supero-marginals, together with the total breadth of the ray at the same levels, is shown in the table below:

	Plate No.						
	2.	5.	10.	15.	20.	25.	
Breadth of ray	25	19	14	10	8	6·5	mm.
,, of paxillar area	15	8·5	5	3·5	2·25	2	,,

The largest paxillæ have a diameter of about 1 mm. and occur on the disk, four of the largest actually on the madreporite. The paxillæ become smaller towards the centre and edges of the disk and along the arms. They are well spaced and arranged in angular chevrons directed towards the centre of the disk. Two chevrons correspond to one supero-marginal, and the number of paxillæ in the chevrons between successive pairs of supero-marginal plates is shown below:

	Plate No.			
	1.	3.	6.	12.
Number of paxillæ	19	13	11	7

The top of one of the larger paxillæ has ten to fifteen short cylindrical bluntly pointed granules in the centre and a ring of thirty to thirty-five longer finer spinelets, which show a tendency to become clavate, radiating from the edge. The base of each paxilla is six-rayed. Papulæ emerge between these rays all over the disk and down the arm nearly to its tip.

There are thirty *supero-marginal plates* forming a broad, gently sloping border to the paxillar area; the infero-marginals, which in the interradius project 2 mm. beyond the supero-marginals, alone define the ambitus. The first supero-marginal is about three-and-a-half times as broad as long. The breadth diminishes on subsequent plates, while the length increases and reaches a maximum at the tenth plate, but it remains less than the breadth to the tip of the ray. Dimensions of supero-marginal plates:

	Plate No.						
	1.	5.	10.	15.	20.	25.	
Length	1·5	2	2	1·75	1·25	1	mm.
Breadth	5·5	5	3·5	3	2·5	2	,,

The surface of the plate is covered with large flat angular granules in five or six irregular rows, while a series of fine clavate spinelets runs along the edges adjacent to the paxillæ and the neighbouring supero-marginal plates. The *infero-marginal* plates correspond exactly with the supero-marginals, and like them are very broad, particularly in the interradius. Each bears about three rows of squamiform granules that are considerably coarser than those of the supero-marginal plates. Towards the outer edge of the plate the squamules become elongated and two, three or even four attain a length of 2 mm. and project as pointed blade-like spines. The spinelets along the other edges of the plate resemble those similarly placed on the supero-marginal plates but are larger and more clavate.

The *actinal intermediate plates* are arranged in four chevrons containing successively twenty-four plates reaching the thirteenth infero-marginal, twelve reaching the sixth, seven reaching the fourth, and four reaching the third infero-marginal. This last chevron encloses three plates, one lying on the interradial line, one on either side of it. Each plate bears on a raised rounded lozenge-shaped tabulum thirty to forty coarse radiating strongly clavate spinelets of which one is often enlarged.

The *adambulacral plates* bear nine or ten long flattened round-tipped furrow spines on a uniformly convex margin. In the centre of the actinal face of the plate three spines stand in an oblique row. These spines are as thick as the furrow spines but only half as long and the axis of flattening is parallel with, instead of at right angles to the furrow. Along the other edges of the plate is a series of about ten spines. Three on the actinal edge resemble the central spines, but those on the edges adjacent to the neighbouring adambulacral plates become finer and shorter as the furrow is approached.

The *mouth plates* bear thirteen furrow spines similar to those of the adambulacral plates and a large number of actinal spines. A row of six round-tipped slightly tapering spines, lying parallel with the furrow, are about half as long as the furrow spines. A second parallel row contains six spines which are a little shorter and in some cases a little thicker. Two irregular rows each containing about six short thick clavate spines lie parallel with the suture between the two adjacent plates. The border adjoining the first adambulacral plate is beset with a number of short fine spines.

Affinities.—I have been able to compare this specimen with examples of two species previously recorded from the Indian Ocean. The British Museum contains a specimen of *D. sladeni* from the Cape of Good Hope. It differs from *D. farquharsoni* in many respects, notably: (i) The paxillæ are smaller and more numerous; (ii) the supero-marginals are almost square throughout; (iii) the infero-marginals are covered with spiniform, not squamiform spinelets, and the enlarged spinelets are much smaller; (iv) the spinelets of the actinal intermediate areas are not clavate. Alcock's type of *D. pentagonalis* was kindly lent by the Indian Museum. It also has but a slight affinity with the present species and differs in the following features: (i) The rays taper less; (ii) the paxillar spinelets are longer and fewer and the peripheral spinelets are not clavate; (iii) the supero-marginals are broader than long but the ratio of these two dimensions is less than in *farquharsoni*; (iv) the infero-marginal spines are round, not flattened; (v) the adambulacral plates have only five furrow spines and one of the actinal spines is enlarged.

The extremely broad supero-marginals of *D. farquharsoni* serve to distinguish it from all other species of *Dipsacaster* except *D. grandissimus* Goto (1914) and *D. pretiosus* Döderlein (1902). The latter is probably the most closely related form, but may be

distinguished by the fewer furrow spines (five), the more abundant granulation on the abactinal and marginal plates, and the enlarged infero-marginal spinelets not projecting beyond the edge of the plate. The infero-marginals of *D. grandissimus* are " uniformly covered with a thick coat of very fine, somewhat flattened spines of a silky appearance ".

The species is named after Lt.-Cmdr. W. I. Farquharson, R.N., navigator and surveyor to the expedition.

Immature Astropectinidæ.

Young forms were taken at the following stations :

St. A, Gulf of Suez, 65–68 m. ;	*Astropecten* sp.	1 specimen.
St. 10, Red Sea, 55 m. ;	,,	1 ,,
St. 34, Gulf of Aden, 1022 m. ;	,,	1 ,,
St. 43, S. Arabian coast, 83–100 m. ;	,,	2 specimens.
St. 66, Gulf of Oman, 609 m. ;	,,	2 ,,
St. 70 ,, ,, 196 m. ;	,,	55 ,,
St. 71, ,, ,, 106 m. ;	,,	1 specimen.
St. 143, Maldive area, 797 m. ;	*Persephonaster* sp.	1 ,,
St. 145, ,, ,, 494 m. ;	Astropectinids,	2 specimens.
St. 171, Central part, Arabian Sea, 3840–3872 m. ;	Astropectinid,	1 specimen.

The specimen from St. A is larger than the rest and, though too small for definite identification, shows features of some interest : R 24 mm., r 8 mm., R/r 3 ; breadth of ray at level of fifth supero-marginal 7 mm., breadth of paxillar area at same level 4 mm. The arms taper to a bluntly pointed tip.

The *paxillæ* are small and closely crowded on the centre of the disk, large and less crowded at the base of the ray, small and well-spaced half-way down the ray where three rows correspond to one supero-marginal plate. Each bears a peripheral series of eight to thirteen short radiating clavate spinelets and usually there is a single central granule, but on the larger plates at the base of the ray there may be as many as five.

There are twenty *supero-marginal plates*, each one a little broader than long and beset with about five irregular rows of well-spaced hemispherical granules which are rather larger than those of the paxillæ. Along the edge of each plate the granules become finer and elongate.

A broad flattened pointed spine, some 2 mm. long, occupies the centre of the upper border of each *infero-marginal plate*. Immediately below it is an oblique row of three or four fine spines, of which the distal is the largest ; it is a little more than half the length of the main spine. On the actinal surface of the plate four or five rather smaller pointed spinelets lie in a row just distal to the median line. On the first two or three plates a second similar row lies on the proximal side of the median line. The rest of the surface of the plate is beset with small well-spaced sharply pointed granules.

On each side of the interradial line there are three *actinal intermediate plates* each bearing a tuft of slightly clavate granules. In one interradius which has been closely scraped there lies what appears to be a rudimentary fourth plate.

The adambulacral plates bear three tapering pointed *furrow spines*, the central a little longer and finer than the others. In the middle of the actinal surface of the plate there are two spines, the distal similar to one of the outer furrow spines, the proximal usually distinctly smaller. Between these two spines and situated nearer the outer border of the plate is a much finer spine.

If this specimen really has four actinal intermediate plates it is very close to, perhaps identical with, the Australian species *A. problematicus* Döderlein (1917, p. 163). The characters of the rest of the body would place it in Döderlein's *scoparius* group, the most nearly related species being *scoparius* itself. This group, however, is biventral, though Döderlein records in one of its members (*kagoshimensis*) the occurrence of three actinal intermediate plates as an abnormality.

Family Luidiidæ.

Döderlein (1920) has monographed this family.

Genus *Luidia* Forbes.

Luidia prionota Fisher.

Luidia prionota, Fisher, 1913*a*, p. 202 ; 1919, p. 164, pl. xli, figs. 5, 5*a*, pl. xlv, figs. 1, 2.

Occurrence :

St. A, Gulf of Suez, 65–68 m., soft yellow mud ; 2 specimens.

Distribution.—Philippines, 20 m. ; Gulf of Suez.

Remarks.—No arms are whole but the minor radii of the two specimens are 7·5 and 9 mm. One specimen has two actinal intermediate pedicellariæ, but, except for these, pedicellariæ are confined to the mouth plates. The adambulacral armature has the same arrangement as in the type, but the relative sizes are rather different. The upcurved furrow spine is about equal to the length of the plate, instead of one-and-a-half times as long as in the type, while the spine just outside it is nearly twice the length of the plate. Of the pair which stands just external to this, the distal spine, is only a little smaller, but the proximal is much shorter and finer, barely half the length of its companion. The spines of succeeding rows are similar to this little one. With this one exception the specimens agree with Fisher's description of the Philippine forms.

Luidia avicularia Fisher.

Luidia avicularia, Fisher, 1913*a*, p. 203 ; 1919, p. 172, pl. xliii, fig. 1, pl. xliv, fig. 2, pl. xlvi, figs. 2, 2*a–c*.

Occurrence :

St. 27, Gulf of Aden, 37–91 m., sand and shell ; 1 specimen.

Distribution.—Philippines ; Gulf of Aden.

Remarks.—Two arms are entire but both are in process of regeneration ; r 16 mm. The abactinal paxillæ are borne on a high rounded arch, beyond which the infero-marginals scarcely project. Down the centre of each arm is a band of paxillæ in six or seven irregular rows. The paxillæ are small and beset with short round-tipped spinelets, two to nine

in the centre, and ten to seventeen rather finer ones peripherally. As far as can be made out there are no paxillar pedicellariæ.

On either side of this median band there are four regular rows of larger paxillæ, the outermost, which is the supero-marginal row, being the smallest. Springing from the centre of nearly every plate of the innermost row is a tapering pointed spinelet, nearly 1·5 mm. in length. Around it are about two rings of spinelets. A few of the paxillæ of the next row bear a similar enlarged central spinelet, but on the two outermost rows a spinelet of the dimensions of those on the two inner rows is never found, though often one spinelet in the centre is a little larger than its neighbours.

The infero-marginal plates bear four or five tapering pointed slightly curved spines, the upper three subequal, about 3 mm. long, the lower one or two somewhat shorter. The edges of the plates have a sparse covering of small, rather broad spinelets.

The adambulacral armature is variable. There is always a flattened upcurved pointed spine projecting across the furrow but never apparently a pedicellaria beneath it. A stout, upright conical spine stands above the furrow spine, and behind it is a similar but smaller spine and then one of the long two-jawed pedicellariæ. One or both may be replaced by a pedicellaria.

This specimen is to some extent intermediate between the Andaman species *L. integra* Koehler and the Philippine species *L. avicularia* Fisher, both of which are founded on a single specimen. It agrees with the former in lacking abactinal pedicellaria, but on account of the occurrence of elongated spinelets on the dorso-lateral paxillæ it is here referred to the species *L. avicularia*.

Immature *Luidiidæ*.

Small forms, all with more than five arms, were taken at the following stations :

St. 24,	Gulf of Aden, 73–200 m. ;	1 specimen.
St. 27,	,, ,, 37–91 m. ;	1 ,,
St. 43,	S. Arabian Coast, 83–100 m. ;	1 ,,
St. 119,	Zanzibar area, 1207–1463 m. ;	1 ,,
St. MB. II*c*,	S. Arabian Coast, 29 m. ;	1 ,,

Family Benthopectinidæ.

Genus *Pectinaster* Perrier.

The table below shows the distribution of the species which are referred to this genus. Sladen's species *Pontaster forcipatus*, *Pontaster forcipatus* var. *echinita* and *Pontaster mimicus* are referred to the genus *Pectinaster* by Perrier (1894, p. 279). Ludwig, in his revision of the family (1910) ranks *Pontaster forcipatus* Sladen and *Pontaster venustus* Sladen as synonyms of *Pectinaster filholi* Perrier, and also transfers to the present genus *Archaster echinulatus* Perrier, *Pontaster pristinus* Sladen, *Pontaster hispidus* Alcock & Wood-Mason, *Pontaster cribrellum* Alcock, and *Cheiraster agassizii* Ludwig. Verrill (1915) transfers *Archaster echinulatus* Perrier to the genus *Cheiraster*, and *Pontaster oligoporus* Perrier and *Cheiraster vincenti* Perrier to the present genus.

Ocean.	Species. (Synonyms in brackets.)	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic .	*filholi* Perrier . .	Perrier, 1894	Many	4	Cape Verde, Azores	1258–2333 m.	Grey or grey-green mud.
		Clark, 1923	11	4	Cape of Good Hope	1422–1828 m.	..
	(*venustus* Sladen) .	Sladen, 1889	..	2	Azores	1645–3702 m.	Pteropod ooze, globigerina ooze.
		Perrier, 1894	51	4	,,	1258–2200 m.	Sand, greenish mud, grey mud.
	(*forcipatus* Sladen) .	Sladen, 1889	..	4	N. America	2260–3108 m.	Blue mud.
	(*forcipatus* var. *echinata* Sladen)	,, ,,	..	1	Between Marion and Crozet Is.	2513 m.	Globigerina ooze.
	pristinus (Sladen) .	,, ,,	..	1	S. America	3748 m.	Blue mud.
	oligoporus (Perrier) .	Perrier, 1894	1	1	West Indies	270 m.	..
		Verrill, 1915	1	1	,, ,,	270 m.	Ooze and sand.
	vincenti (Perrier) . .	Perrier, 1894	..	..	,, ,,	..	..
		Verrill, 1915	6	1	,, ,,	166 m.	..
	mixtus Verrill . .	,, ,,	Many		,, ,,	151–434 m.	..
	gracilis Verrill . .	,, ,,	"Very common"		,, ,,	126–540 m.	..
	dispar Verrill . .	,, ,,	1	1	,, ,,	..	..
Pacific .	*agassizii* (Ludwig) .	Ludwig, 1905	596	9	Gulf of Panama, Gulf of California, Galapagos Is.	1271–2323 m.	Globigerina ooze and mud.
		Clark, 1913	96	7	S. California	811–1990 m.	..
		,, 1920	11	1	Gulf of Panama	1393 m.	Green sand.
		,, 1923	44	..	S. California	792 m.	..
	agassizii subsp. *evoplus* Fisher	Fisher, 1911	227	3	,,	1798–1935 m.	Grey and green mud.
	robustus A. H. Clark .	Clark, 1917	1	1	Off Chile	2415 m.	..
Eastern Archipelago	*mimicus* (Sladen) .	Sladen, 1889	..	1	Arafura Sea	1463 m.	Green mud.
		Fisher, 1919	13	7	Flores Sea, Macassar Strait, Celebes	1264–1995 m.	Grey and green mud.
	mimicus subsp. *palawanensis* Fisher	,, ,,	6	1	Palawan Passage	1334 m.	Coral sand.
	mimicus subsp. *malayanus* Döderlein	Döderlein, 1921	14	6	Celebes	1018–1914 m.	Grey and green mud.
	hylacanthus Fisher .	Fisher, 1913*a*	34	4	Philippines	700–800 m.	,, ,, sand.
	mimicus subsp. *hylacanthus* Döderlein	Döderlein, 1921	11	4	Moluccas	724–924 m.	Grey and blue mud.
Indian .	*mimicus* (Sladen) .	Alcock, 1893	..	..	Laccadive Sea	1828 m.	Olive mud.
	hispidus (Alcock & Wood-Mason)	Alcock and Wood-Mason, 1891	..	..	,, ,,	1828 m.	Green mud.
		Koehler, 1909	8	7	Arabian Sea to Gulf of Oman	877–2473 m.	..
	cribrellum (Alcock) .	Alcock, 1893	..	..	Laccadive Sea	2192 m.	Coral and globigerina ooze.

Pectinaster agassizii (Ludwig).

Cheiraster agassizii, Ludwig, 1905, p. 1, pl. i, figs. 3, 4, pl. ii, figs. 5–12, pl. xvi, figs. 81–84.
Pectinaster agassizii, Ludwig, 1910, p. 449.

Occurrence :

St. 185, Gulf of Aden, 2001 m., green mud ; 2 specimens.

Distribution.—Gulf of Panama, Gulf of California, Galapagos Is. ; Gulf of Aden.

Description.—The measurements of the two specimens are : larger, R 119 mm., r 17 mm., R/r 7 ; smaller, r 14 mm. The *abactinal paxillæ* are of two kinds, the smaller uniformly granular, the larger with a ring of granules surrounding a central spinelet. In the smaller specimen the abactinal surface is in better condition, and these spinelets can be detected everywhere, though they become smaller as the tip of the ray is approached and are not visible to the naked eye much beyond the middle of the ray.

The *papularia* are oval, the radial axis a little longer than the tangential. Each contains forty to fifty pores.

The larger specimen has thirty-three *supero-marginal plates*, which are small, confined to the side of the ray, and armed with a robust pointed spine 4 to 5 mm. long. The first two or three plates are closely covered by fine elongate granules ; on succeeding plates the granules become scarcer, and a small area below the spine is bare.

On the lateral face of each *infero-marginal plate* there is a spine similar to that of the supero-marginal above, and on the actinal face stands a second spine like it but between a third and one-half the size. The granulation is coarser and more uniform than that of the supero-marginal plates, and about the base of the larger spines there are often two or three spinelets.

The *actinal intermediate areas* extend to the sixth infero-marginal plate. The plates are beset with short cylindrical spinelets, round-tipped or pointed, about 0·5 mm. in length. Springing from the centre of some of the plates is a tapering pointed spine which may attain a length of 2 mm., though usually it is less. Fasciolar pedicellariæ are numerous.

Seven *adambulacral furrow spines* are set on an angular border. The central spine is the longest, and there is a progressive decrease in size to the outermost, which is barely half as long. Four or five small spines along the proximal border of the plate appear to continue the furrow series. There is a robust conical spine about 3 mm. long in the centre of the actinal surface of each plate. Sixteen adambulacral plates correspond to ten infero-marginals.

From the inner corner of each *mouth plate* two stout tapering spines, of which the inner is a trifle the larger, project into the mouth cavity. Projecting into the furrow are six smaller spines which show a regular decrease in size from the proximal to the distal end of the series. Two large conical spines stand on the actinal surface of each plate, together with a number of small cylindrical spines, of which a series of four lie parallel with the furrow, while eight in two irregular rows lie parallel with the median suture.

Affinities.—A doubt as to whether these two specimens have been correctly identified will persist until they have been compared side by side with an example of *P. agassizii*. Both, however, agree closely with Ludwig's description, and the only difference is that, whereas the present examples have but one supero-marginal spine, specimens of smaller dimensions from the East Pacific have two. I do not think this character affords sufficient grounds for separation.

The most closely related species is *P. mimicus* Sladen. This form has the abactinal spinelets confined to a central band and a uniform actinal intermediate granulation. It may be separated on yet a third character, not mentioned in Ludwig's key, namely, the smaller number of papulæ.

Pectinaster agassizii granuliferus subsp. n.

OCCURRENCE :

St. 26. Gulf of Aden, 2312 m., soft grey white mud ; 3 specimens.

One specimen is small (R 33 mm.). The other two are well-grown and have the following characters : (i) R 158 mm., r 20 mm., R/r 7·9, number of papulæ 40, number of supero-marginal plates 45 ; (ii) r 8·5 mm., number of papulæ 25. The specimens are very close to *P. agassizii* Ludwig, of which two examples were obtained at St. 185, and the description is therefore given in the form of a comparison.

DIAGNOSIS.—Close to *P. agassizii*, differing in three particulars : abactinal spinelets confined to a central band ; abactinal and intra-marginal pedicellariæ present ; granules instead of spinelets on the actinal plates.

DESCRIPTION.—On the *abactinal surface* an occasional pectinate pedicellaria is found, and the paxillæ with central spinelets are absent from a band some 2 mm. broad adjoining the supero-marginal plates. In *P. agassizii* these paxillæ occur all over the abactinal surface.

In the larger specimen the proximal *supero-marginal plates* bear two spines, the longer measuring 4 mm., the shorter 3 mm. The granulation is similar to that of *P. agassizii* in distribution but it is shorter. Whereas the granules of *P. agassizii* are definitely capillary, those of this subspecies are papilliform. Pedicellariæ are found between the first two or three supero-marginal and infero-marginal plates. The *infero-marginals* are similar to those of *P. agassizii*, but in the larger specimen they bear three, instead of two, spines.

The pedicellariæ of the *actinal intermediate areas* are similar to those of *P. agassizii* but rather more numerous. The plates are bordered by rather few short hemispherical or pointed granules, and on account of this the actinal surface has a facies distinctly unlike that of *P. agassizii*, in which the armature is more abundant and spiniform. This subspecies has, however, an elongate conical spine in the centre of many of the plates.

The furrow spines of the *adambulacral plates* are arranged as in *P. agassizii* but they are a little shorter, and the series along the proximal border of the plate is granuliform instead of spiniform.

AFFINITIES.—The subspecies *granuliferus* differs from *P. agassizii evoplus* Fisher in the restriction of the abactinal spinelets, in the granular actinal intermediate armature and in having fewer pores. The first two characters suggest the group of species to which *P. mimicus* Sladen, *P. filholi* Perrier and *P. hispidus* Alcock & Wood Mason belong, but all these have a uniform actinal intermediate armature and a relatively small number of pores.

Genus *Benthopecten* Verrill.

Ludwig (1910) in his revision of the *Notomyota* retains *Benthopecten* Verrill and *Pararchaster* Sladen as distinct genera. Fisher (1911, p. 143) points out certain difficulties which arise if this step is taken and unites the two genera. The distribution of the genus *Benthopecten* in the extended sense demanded by Fisher is as follows :

Occan.	Species. (Synonyms in brackets.)	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic .	*spinosus* Verrill . .	Verrill, 1899, 1915	Many records		Coast of U.S.A., Gulf of Mexico	1300–3600 m.	. .
		Grieg, 1932	18	3	N. Atlantic	1100–1853 m.	. .
		Mortensen, ?	. .	. .	S. Iceland	2094 m.	. .
	(*armatus* Sladen) .	Sladen, 1889	. .	3	Nova Scotia, New Jersey, Portugal	2284–2466 m.	Blue mud.
		Farran, 1912	30	1	Ireland	1744 m.	Ooze.
	(*semisquamatus* var. *occidentalis* Sladen)	Sladen, 1889	1	1	Coast of U.S.A.	3108 or 2266 m.	Blue mud.
	(*fischeri* Perrier) .	Perrier, 1894	1	1	Coast of Africa	1056–1435 m.	. .
	spinosissimus (Sladen) .	Sladen, 1889	1	1	Ascension	756 m.	Volcanic mud.
	simplex (Perrier) . .	Perrier, 1881	1	1	Gulf of Mexico	2420 m.	. .
	folini (Perrier) . .	,, 1894	10	3	Coast of Africa	2300 m.	. .
Southern .	*antarcticus* (Sladen) .	Sladen, 1889	2	1	Challenger's most southern dredging	3000 m.	Blue mud.
	pedicifer (Sladen). .	,, ,,	. .	2	Crozet Is. Aghulhas bank	2925 m. 3473 m.	Diatom ooze. Globigerina ooze.
Pacific .	*acanthonotus* Fisher .	Fisher, 1905	7	2	S. California	1794–1900 m.	Mud.
	mutabilis Fisher . .	,, 1910	8	1	British Columbia	2876 m.	Globigerina ooze.
	claviger Fisher . .	,, ,,	16	4	Bering Sea to Oregon	1794–1900 m.	Green mud or ooze.
	pectinifer (Ludwig) .	Ludwig, 1905	37	3	Galapagos, Gulf of Panama, Gulf of California	1571–2323 m.	Globigerina ooze, brown mu[d]
	cognatus (Ludwig) .	,, ,,	1	1	Gulf of Panama	3035 m.	Sand.
	spinuliger (Ludwig) .	,, ,,	25	4	Galapagos Is., Cocos Is., Gulf of Panama	1618–2323 m.	Globigerina ooze.
Eastern Archipelago	*moluccanus* Fisher .	Fisher, 1913*a*	9	2	Molucca Passage	417–435 m.	Grey sand and mud.
	polyctenius Fisher .	,, ,,	12	2	Celebes	1475 m.	. .
	styracius Fisher .	,, ,,	2	1	Macassar Strait	1645 m.	Grey mud.
	semisquamatus subsp. *celebensis* Döderlein	Döderlein, 1921	9	4	Celebes	1688–3437 m.	Green and grey mu[d]
Indian .	*huddlestonii* (Alcock) .	Alcock, 1893	. .	. .	Bay of Bengal	2778 m.	Globigerina ooze.
	violaceus (Alcock) .	,, ,,	. .	. .	Laccadive Sea	2193 m.	Coral and globigerin[a] ooze.
	indicus (Koehler). .	Koehler, 1909	1	1	S. of Ceylon	834–1076 m.	. .
Indian to Pacific	*semisquamatus* (Sladen)	Sladen, 1889	. .	2	Japan	1875–1114 m.	Blue mud, green mu[d]
		Alcock and Wood-Mason, 1891	1	1	Bay of Bengal	3041 m.	Globigerina ooze.

Benthopecten heteracanthus sp. n.

Occurrence :

St. 26, Gulf of Aden (African coast), 2312 m., soft grey white mud ; 1 specimen.

Diagnosis.—R/r 8·4. Abactinal plates with one to four papilliform spinelets ; spines occurring only in two rings, one of five around the anus, the other of ten some 7 mm. from the first and on the madreporite. Papulæ extending to about sixth supero-marginal plate. Supero-marginals confined to side-wall of disk and ray ; armed with a single robust tapering pointed spine, encircled by three or four spinelets ; five unpaired interradial supero-marginals, each armed with one very large spine and three accessory spines. Infero-marginals almost directly below supero-marginals ; bearing two spines ; pedicellariæ between infero-marginals almost to tip of ray. Actinal interradial areas small, with usually four pedicellariæ and a few spinelets. Adambulacral plates with seven to eleven small clavate furrow spines and two larger actinal spines. Mouth plates with two spines projecting into mouth cavity, four projecting into furrow and three spines on actinal surface.

Description.—R 210 mm., r 25 mm. In the centre of the disk there is a ring of five spines, each 4 mm. long, slightly tapering and rounded at the tip. Ten similar spines on the radii and interradii stand at a distance of 7 mm. from this central group and, except for two spines on the edge of the madreporite, are the only spines found on the abactinal surface. The remaining plates bear projections which are little more than papillæ, not quite 1 mm. in length. Most plates bear but a single papilla, but two or three, or even four, occur on some. The madreporite lies on an interradius a little nearer the edge than the centre of the disk. Papulæ are present on that portion of the disk which lies without the outer ring of spines, and extend down the rays in two attenuating bands as far as the level of the fifth or sixth supero-marginal plate. There are no abactinal pedicellariæ.

The *supero-marginal plates* number about fifty. They are confined to the side of the disk and ray and are all longer than high. Each bears a tapering pointed spine, the longest (on the sixth plate) measuring 13 mm. Near the proximal edge of each plate there are sometimes one or two minute spinelets, and round the base of the boss on which the main spine stands there is always a ring of slightly larger spinelets, 1 to 2 mm. long On the first two or three plates one of these encircling spinelets reaches a length of 5 mm. and may be ranked as an accessory spine. An unpaired plate is present in each interradius, and bears one spine, 18 mm. long, and three accessory spines, 5 to 6 mm. long.

The *infero-marginals* encroach very little on to the actinal surface and lie almost directly beneath the supero-marginals, which they resemble in size. Each bears two spines, one below the other, the upper nearly as long as, but finer than, the corresponding supero-marginal spine, the lower between one-half and two-thirds the size of the upper. A few minute spinelets may occur at random on the surface of the plate, but there is always a regular row of five or six along the border adjacent to the adambulacral plates. Fasciolar pedicellariæ occur between adjacent infero-marginals and can be traced almost to the tip of the ray. Ten infero-marginals correspond to seventeen or eighteen adambulacral plates.

The *actinal intermediate areas* are small and the outline of the plates is obscured by membrane. Two, or in one case three, fasciolar pedicellariæ stand on either side of the interradial line. A few spinelets are also present.

The furrow margins of the *adambulacral plates* are rounded and those near the mouth bear seven or eight spines, which are slightly clavate and small, the largest measuring little more than 1 mm. in length. Three subequal spines stand close together and occupy the centre of the margin, while a fourth, also of much the same size, stands a little apart distally. On either side of this central group are found one or two smaller spines spaced at intervals nearly equal to their length. On the outer half of the ray the total number of spines is eleven. There is a central group of six with two or three smaller spines on either side, but owing to the increase in numbers these are not so far apart as on the proximal plates. The actinal surface of the plates supports two, usually equal, tapering pointed spines, 4 to 5 mm. in length.

The free edge of the *mouth plates* bears six spines. Two of these project into the mouth cavity. They are cylindrical and rounded at the tip ; the inner, which is a trifle the larger, is 4 mm. long. The remaining four spines project into the furrow and are similar to the furrow spines of the adambulacral plates. The largest is nearest the mouth and the remainder show a progressive decrease in size. On the actinal surface of the plate there are three spines similar to the two projecting into the mouth cavity but smaller. They show a regular decrease in size from the proximal to the distal end of the series.

Affinities.—The affinities of this species lie within a complex of three, comprising *B. violaceus* (Alcock), *B. styracius* Fisher and *B. polyctenius* Fisher. The species are compared in the table below :

	Spine on unpaired SMP.	Number of spinelets on abact. plates.	Accessory spines on SMPs.	Abactinal pedicellariæ.	Limit of papulæ.	Extent of pedicellariæ on IMPs.	Number of act. int. pedicellariæ.	Number of furrow spines.	Number of spines per IMP.	Number of adamb. plates = 10 IMPs.
B. heteracanthus .	Very large	1–4	Present	Absent	6th SMP.	Far along ray	2	7–11	2	17–18
B. violaceus .	Large	2–4	,,	,,	2nd SMP.	To 4th IMP.	2	7–8	2	24
B. styracius .	Very large	1–2	Absent	Present	3rd SMP.	Far along ray	2	7–8	2	19–22
B. polyctenius .	4 equal	5–8	Present	,,	4th SMP.	Ditto	8–12	9–14	2	20

Thus *B. heteracanthus* differs from *B. violaceus* in the greater extent of the papulæ and infero-marginal pedicellariæ, more numerous furrow spines, less numerous abactinal spinelets, fewer adambulacral plates to ten infero-marginals, and a larger spine on the unpaired supero-marginal. It is perhaps closest to *B. styracius*, from which it differs in the absence of abactinal pedicellariæ, the greater extent of the papulæ, more numerous furrow spines and fewer adambulacral plates to ten infero-marginals. As Fisher (1919, p. 213) points out, the type of *B. violaceus* is probably but half-grown, and in the adult condition would be likely to have more numerous pedicellariæ, more numerous abactinal spinelets and more numerous furrow spines. In one of his Pacific species, *B. acanthonotus*, Fisher (1911, p. 145) records variability in the extent of the papulæ areas. It is probable,

therefore, that the four species stand closer than is indicated by a comparison of the characters of the very meagre number of examples at present known. For the moment, however, there is not enough evidence to regard them as anything but distinct species.

Immature *Benthopectinidæ*.

St. 107, Zanzibar area, 421–457 m.; *Luidiaster* sp., 1 specimen.
St. 118, ,, ,, 1789 m.; *Pectinaster* sp., 1 specimen.
St. 123, ,, ,, 256–366 m.; *Luidiaster* sp., 1 specimen.

Family GONIASTERIDÆ.

Sub-family PSEUDARCHASTERINÆ.

Genus *Pseudarchaster* Sladen.

The species of this genus are distributed as follows:

Ocean.	Species.	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic .	*annectens* (Perrier) .	Perrier, 1894	1	1	N. coast of S. America	900 m.	..
		Koehler, 1895	1	1	Coast of France	1410 m.	..
		Perrier, 1896	5	1	,, ,,	1384 m.	Sand and pteropods.
		Koehler, 1909*a*	4	4	Azores	1550–1900 m.	Globigerina ooze; mud and sand; sand and rock
	hystrix (Perrier) . .	Perrier, 1894	1	1	Coast of Morocco	840 m.	Yellow mud.
	fallax (Perrier) . .	,, 1885	17	4	Azores	1440–2220 m.	Grey mud.
		Koehler, 1909*a*	2	2	,,	1165–1385 m.	Sandy mud.
		Grieg, 1932	2	1	Newfoundland	1100 m.	..
	necator (Perrier) . .	Perrier, 1894	1	1	Azores	1275 m.	Grey mud.
		Koehler, 1909*a*	1	1	,,	1900 m.	Globigerina ooze.
	hispidus Verrill . .	Verrill, 1899	1	1	West Indies	1097 m.	..
	granuliferus Verrill .	,, ,,	1	1	,, ,,	..	..
	concinnus Verrill .	,, 1895, 1899	..	3	American coast	2138–3203 m.	..
	ordinatus Verrill .	,, 1899	..	2	Gulf of Mexico	583–603 m.	..
	gracilis (Sladen) . .	Sladen, 1889	..	1	Azores	1800 m.	Volcanic mud.
	aphrodite (Perrier) .	Perrier, 1894	..	..	Coast of Sahara	1090 m.	..
	æquabile (Koehler) .	Koehler, 1909*a*	1	1	Azores	1900 m.	Globigerina ooze.
	eminens (Koehler) .	,, ,,	4	3	,,	1095–1940 m.	Sandy mud; mud and sand; volcanic sand.

Ocean.	Species.	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic —*cont.*	*marginatum* (Koehler) .	Koehler, 1909*a*	1	1	Azores.	1805 m.	Sandy mud.
	parelii (Düben & Koren)	N. Atlantic, Europe to America.			Many records, *see* Fisher, 1911, Goto, 1914.		
Pacific .	*intermedius* Sladen .	N. Pacific, Asia	,,		,, ,,		,,
	discus Sladen . .	Sladen, 1889	. .	1	Patagonia	267 m.	Blue mud.
	patagonicus (Perrier) .	Perrier, 1891	1	1	,,	283 m.	. .
	pusillus Fisher . .	Fisher, 1904, 1911	461	20	California	96–694 m.	Various.
		Clark, 1913, 1923	48	1	S. California	511 m.	. .
	dissonus Fisher . .	Fisher, 1911	5	3	Oregon to Bering Sea	1436–1944 m.	Green mud.
	pulcher Ludwig . .	Ludwig, 1905	4	3	Galapagos Is.	702–1618 m.	Mud, sand, globigerina ooze.
	verrilli Ludwig . .	,, ,,	1	1	Gulf of Panama	998 m.	Blue mud.
	myobrachius Fisher .	Fisher, 1906	3	2	Hawaii	779–1234 m.	Sand and rock.
	pretiosus Döderlein .	Döderlein, 1902	. .	. .	Japan	20–30 m.	. .
		Goto, 1914	13	4	,,	20–480 m.	. .
	pectinifer Ludwig .	Ludwig, 1905	1	1	Gulf of Panama	1865 m.	Green mud.
		Clark, 1913	1	1	S. California	1164 m.	. .
		,, 1920	2	1	Coast of Peru	1864 m.	Dark brown mud.
		Döderlein, 1924	2	2	Eastern Archipelago	724–1018 m.	Grey mud.
	alascensis Fisher, 1904 = *parelii alascensis* Fisher, 1911	Fisher, 1911	9	6	Alaska	122–1915 m.	Rocks and coarse sand, rocks, mud, green mud.
	abnormale (Bell) . .	Benham, 1900, 1909	. .	. .	New Zealand	20–50 m.	. .
	huttoni (Farquhar) .	Farquhar, 1897	. .	. .	,, ,,	. .	. .
	boardmani Livingstone .	Livingstone, 1934	4	2	Australia	135–162 m.	Sand and clay.
Eastern Archipelago	*oligoporus* Fisher .	Fisher, 1913	3	2	Celebes	1992 m.	Green and grey mud.
	spatuliger Mortensen .	Mortensen, 1934	. .	. .	Hong Kong	. .	. .
Indian .	*mozaicus* (Alcock & Wood-Mason)	A. & W.-M., 1891	. .	. .	Andaman Sea	352–400 m.	Green mud.
		Koehler, 1909	15	8	,, Bay of Bengal, Gulf of Oman S. India	584–1794 m.	. .
	roseus (Alcock) . .	Alcock, 1893	. .	. .	Laccadive Sea	1352 m.	Coral mud.
	brachyactis Clark .	Clark, 1925	. .	. .	Cape of Good Hope	365–731 m.	Green sand.
	tessellatus Sladen .	Sladen, 1889	. .	1	,, ,,	. .	. .
		Clark, 1925	4	. .	,, ,,	155 m.	Green sand.
		Mortensen, 1933	Many		,, ,,	170–320 m.	. .
Pacific to Indian	*jordani* Fisher . .	Fisher, 1906	2	1	Hawaii	685 m.	Fine white sand.
		,, 1913	54	4	Borneo and Moluccas	785–1627 m.	Green and grey mud.
		Koehler, 1909	. .	. .	S. India Arabian Sea	814–1982 m.	. .

Pseudarchaster mozaicus Alcock & Wood-Mason. (Pl. II, figs. 1 and 10 ; Text-fig. 2.)

Pseudarchaster mozaicus, Alcock & Wood-Mason, 1891, p. 432 ; Alcock, 1893, p. 85.
Astrogonium mozaicum, Koehler, 1909, p. 50, pl. i, fig. 3.

Occurrence :

St. 108, Zanzibar area, 786 m., grey mud ; 1 specimen.
St. 115, ,, ,, 640–658 m. ; 1 specimen.
St. 122, ,, ,, 732 m., grey green mud ; 2 specimens.

Distribution.—Andaman Sea, Gulf of Oman, Bay of Bengal ; Zanzibar area ; 352 to 1794 m.

Description :

R . .	94 .	80 .	72 .	60 mm.
r . .	27 .	23 .	20 .	17 ,,
R/r . .	3·4 .	3·5 .	3·6 .	3·5

The following description is taken from the largest specimen. The body is flat. The arms taper and are pointed at the tip. The abactinal paxillæ lie in regular radial and transverse rows. The following table shows the dimensions of the arms and the number of paxillæ at the level of successive supero-marginal plates :

	SMP. No.			
	4.	8.	16.	24.
Breadth of arm . .	26 .	17 .	12 .	6 mm.
Breadth of paxillar area .	15 .	7 .	4 .	2 ,,
Number of paxillæ . .	11 .	9 .	7 .	2

The *carinal plates* are round with a diameter of 1 mm. or a little more. Each is covered with granules, of which the central are large, hemispherical and well spaced, while those of a peripheral series are less than half the size, slightly clavate and alternating with the central series. A few granules are intermediate in size, but appear to belong to the peripheral series. If this be the correct interpretation, the arrangement is eight to fourteen central granules and twenty to twenty-five peripheral granules.

The *supero-marginals* are thirty-four in number. They form a broad border to the paxillar area and curve round to meet the infero-marginals, the curve becoming more abrupt towards the outer edge of the plate. The breadth in the interradius is between two-and-a-half and three times the length. The length increases slightly up to the sixth or eighth plate while the breadth decreases uniformly to the tip of the ray, though it remains the greater dimension throughout as is shown in the following table :

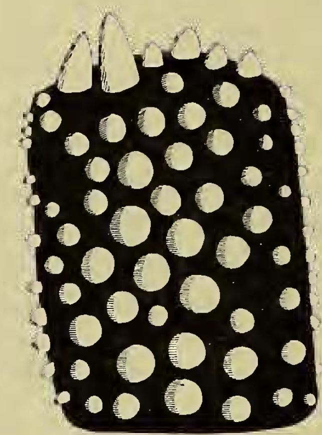
	Plate No.			
	1.	4.	8.	16.
Breadth	6 .	5·5 .	5 .	4 mm.
Length	2 .	2·5 .	4 .	2 ,,

The plates are beset with five to eight irregular rows of well-spaced granules which become larger towards the centre of the plate. At the outer border of each plate four or

five of the granules are conical, and one or two are elongated and project as conspicuous blunt conical spinelets about 1 mm. long (Text-fig. 2).

The *infero-marginals* correspond to the supero-marginals and like them decrease regularly in breadth from the interradius to the tip of the ray, while the length shows a slight increase up to the sixth or eighth plate. There are six or seven rows of pointed spinelets and each row has larger spinelets than the row outside it. About half-a-dozen spinelets in each of the two innermost rows are longer than all the rest and reach a length of 1·5 mm.

The *actinal intermediate areas* reach the sixth or seventh infero-marginal. The limits of the plates are obscured by membrane, but they are marked by pointed granules,



Text-fig. 2.—*Pseudarchaster mozaicus* Alcock & Wood-Mason. (From St. 122.) 8th supero-marginal plate × 8.

and in the centre of each plate there are one, or occasionally two, spinelets whose length, 2 mm., is four to five times that of the peripheral granules.

On the angular furrow margin of the *adambulacral plates* there are six to eight tapering pointed spines, and on the actinal surface there are two rows of five or six spines, which are usually all shorter than the furrow spines, though sometimes one to three of the inner row may be of the same length. Proximally there are about eight fasciolar pedicellariæ.

Colour.—Paxillar area, vinaceous lilac ; marginal plates and actinal surface, pale flesh colour.

Affinities.—I have been able to compare these specimens with an example of *P. mozaicus* from the Indian Museum and I have no hesitation in referring them to this species, although there are some small details, tabulated below, in which they differ from it and approach *P. jordani* Fisher, a species typically without supero-marginal armature :

Species.	Granulation of carinal paxillæ. Central.	Granulation of carinal paxillæ. Peripheral.	Number of rows of granules on SMPs.	Number of furrow spines.	Number of adamb. act. spines.
P. mozaicus	5–7	20–25	About 5	5	8
P. jordani	15–18	10–12	7–8	6–7	12–20
P. mozaicus, Zanzibar specimens	8–14	20–25	5–8	6–8	10–12

Pseudarchaster diversigranulatus sp. n. (Text-fig. 3.)

Occurrence :

St. 26, Gulf of Aden, 2312 m., soft grey-white mud ; 2 specimens.

St. 59, Ras el Hadd, Arabia, 1948 m., soft green mud ; 1 specimen.

Diagnosis.—Arms tapering, pointed. Paxillar area large ; paxillæ in regular radial and transverse series ; large, with round clavate central granules and a peripheral series of only slightly smaller, flattened, subtruncate granules. Supero-marginal plates narrow ; with characteristic granules, those along adjacent edges forming a fasciolar apparatus, those in the centre hemispherical, two to four much enlarged, those near the outer border conical, one or two enlarged. Infero-marginals corresponding to supero-marginals ; armed with rows of fine pointed spinelets, those of the middle rows longest. Actinal intermediate areas large ; plates beset with bluntly pointed spinelets of which two or three in the centre are elongated. Adambulacral plates with furrow series of six or seven short round-tipped spines on convex margin ; remaining margins of plate with about seven similar smaller spines ; centre occupied by three pointed spines which may be longer than those of furrow series.

Description.—St. 59, R 93 mm., r 25 mm., R/r 3·7 ; St. 26, R 52 mm., r 16 mm., R/r 3·3 ; R 50 mm., r 15 mm., R/r 3·3.

The following table shows the breadth of the arm and the paxillar area, and the number of paxillæ at the level of successive supero-marginal plates :

	SMP. No.			
	4.	8.	16.	24.
Breadth of arm . . .	23	17	13	8 mm.
,, of paxillar area .	13	9	5	4 ,,
Number of paxillæ . .	17	15	9	5

The above table and the following description are taken from the largest specimen. The paxillæ are arranged in regular radial and transverse rows, and are large, for the diameter of those in the carinal row is about 2 mm. The top of such a paxilla is hemispherical, and on it there are fourteen to sixteen large round well-spaced clavate granules, while round the rim runs a series of about twenty granules which are of almost the same size as those in the centre but differ in being rather flattened and subtruncate. The paxillæ of the ray are not elongated. Papulæ extend about two-thirds of the way down the arm.

The *supero-marginal plates* number forty. The breadth of the first plate is a little over twice the length ; of the next five or six plates each is a little broader than the one before, the next ten or twelve plates are of the same breadth and the remainder decrease uniformly in breadth to the tip of the ray ; the length increases up to the ninth or tenth plate and then decreases. Dimensions :

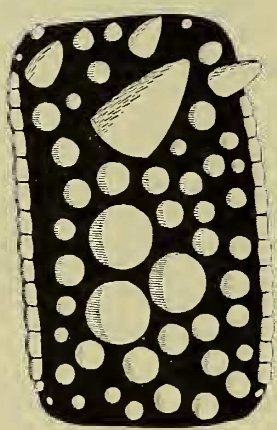
	Plate No.				
	1.	4.	8.	16.	24.
Breadth .	4·5	5	4	4	2 mm.
Length . .	2	2·5	3	2	1·5 mm.

The edge of each supero-marginal bears a series of small subtruncate granules which are apposed to those of the neighbouring plates in such a manner as to form a fasciolar apparatus. The rest of the plate is occupied by about four irregular rows of hemispherical granules of which two to four are considerably larger and more protuberant than the

rest. Near the outer border of the plate, just above the infero-marginal, the granules are pointed and one or two stand out as coarse conical spinelets. These spinelets are most conspicuous about half-way down the ray (Text-fig. 3).

The *infero-marginal plates* correspond exactly with the supero-marginals. The plates are separated by fasciolar grooves, and the surface is beset with about six rows of pointed spinelets. Those of the outer row are the shortest, those of the inner row, with a length of about 1 mm., the longest.

The *actinal intermediate areas* extend to the eleventh infero-marginal. The boundaries of the plates are obscured by membrane, but each is apparently armed with twelve to fifteen short bluntly pointed spinelets. Two or three of these stand in the centre of the plate and are longer than the rest, which are set round the edge. Of the central spines one is often a trifle longer than the others and may be 1·5 mm. long. Between the proximal half-dozen plates of the innermost chevron there is a fasciolar pedicellaria.



Text-fig. 3.—*Pseudarchaster diversigranulatus* sp. n. (From St. 59.) 8th supero-marginal plate × 8.

The *adambulacral plates* bear six or seven short round-tipped furrow spines, about 1 mm. long, on a regularly convex margin. The furrow series appears to be continued right round the plate by some seven similar but rather smaller spines. In the centre stand three pointed spines, some or all of which may be longer than the furrow spines.

Remarks.—The two smaller forms from St. 26 appear to belong to the same species. They show the enlarged supero-marginal granules, but those on the outer edge of the plates are not pointed.

Affinities.—The largest specimen of *P. diversigranulatus* is of almost exactly the same size as the largest *P. mozaicus*. Comparison reveals a number of small differences. The upper tables on pp. 357 and 359 show that the shape of the arm is different in the two species, and that in *P. diversigranulatus* each radial row of paxillæ extends considerably farther down the arm than in *P. mozaicus*. The paxillæ of *P. diversigranulatus* are larger, more uniformly granulated and do not become elongated down the rays. Of the two species *P. diversigranulatus* has narrower supero-marginal plates* (*cf.* tables, pp. 357 and 359), and their granulation is characteristic. There are also conspicuous differences in the armature of the infero-marginal, actinal intermediate and adambulacral plates of the two species.

* Text-figs. 2 and 3 are not drawn from the same angle. The supero-marginal of *P. diversigranulatus* (Text-fig. 3) has been drawn somewhat from the side and so appears to be broader than the corresponding plate of *P. mozaicus* (Text-fig. 2).

Genus *Paragonaster* Sladen.

Distribution.—The records of the occurrence of the various species of this genus are shown in the following table :

Ocean.	Species. (Synonyms in brackets.)	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic	*subtilis* (Perrier)	Perrier, 1881, 1884, 1894	3	3	Gulf of Mexico, Cape Verde Is., Azores	3530 m. 3655 m. 2995 m.	..
		Koehler, 1909*a*	7	4	,, Cape Verde Is.	3890–4261 m.	White mud, sandy mud, globigerina ooze.
		Grieg, 1932	3	1	Coast of Spain	4700 m.	Yellow sand.
	(*cylindratus* Sladen)	Sladen, 1889	1	1	Cape Verde Is.	2382 m.	Globigerina ooze.
	(*elongatum* Perrier)	Perrier, 1884	3	3	Azores	2996–4060 m.	White clay, pumice.
	(*strictus* Perrier)	,, 1894	3	1	Canary Is.	3655 m.	Grey mud.
	(*formosus* Verrill)	Verrill, 1884, 1895	..	15	Coast of New England	2512–3690 m.	..
Eastern Archipelago	*ctenipes* Sladen	Sladen, 1889	..	1	Banda Sea	255 m	Blue mud.
	ctenipes var. *hypacanthus* Fisher	Fisher, 1913, 1919	34	11	Philippines	207–313 m	Green mud; grey mud; sand and mud; globigerina ooze.
		Döderlein, 1924	3	2	Timor Sea	216–310 m.	Grey mud; coral sand.
	stenostichus Fisher	Fisher, 1913, 1919	8	2	Philippines	220–360 m.	Sand and broken shell; mud and sand.
		Döderlein, 1924	1	1	Kei Island	310 m.	Grey mud.
Indian	*tenuiradiis* Alcock	Alcock, 1893	..	..	Bay of Bengal	3195 m.	Globigerina ooze and pumice.

Paragonaster stenostichus Fisher.

Paragonaster stenostichus, Fisher, 1913, p. 627 ; 1919, p. 232, pl. 60, fig. 2, pl. 70, fig. 2, pl. 71, fig. 1, pl. 91, figs. 10, 10*a* ; Döderlein, 1924, p. 50.

Occurrence :

St. 105, Zanzibar area, 238–293 m., green mud ; 1 specimen.

St. 110, ,, ,, 347–384 m., grey-green mud and sand ; 1 specimen.

Distribution.—Philippine Islands, Banda Sea ; Zanzibar.

Description.—

	R, mm.	r, mm.	R/r.	Number of SMPs.	Breadth of arm at level of successive SMPs., mm.				Breadth of paxillar area at level of successive SMPs., mm.			
					4th.	8th.	15th.	30th.	4th.	8th.	15th.	30th.
(1).	92	25	3·6	38	19	14	10	4·5	12	5	1	0·5
(2)	80	22	3·6	36	18	13	9	4·5	10	3·5	1	0·5

The breadth of the arm and of the paxillar area in this table is measured across the distal edge of the supero-marginal plates.

The *abactinal paxillæ* are hexagonal, with nineteen to twenty-one polygonal central granules and twenty to twenty-five smaller truncate peripheral granules. Beyond the level of the eighth supero-marginal plate the carinals become rectangular, the length being greater than the breadth. They extend to the tip of the ray, while the first lateral row of plates reaches about the fifteenth, and the second lateral row of plates about the tenth supero-marginal.

The *supero-marginal plates* are broader than long. The breadth decreases uniformly from the first plate, while the length increases up to the eighth plate and thence decreases, remaining, however, less than the breadth to the tip of the ray. The surface of each plate is covered with coarse polygonal granules, which are larger in the centre. The *infero-marginals* correspond with the supero-marginals. They are covered with squamiform granules from among which spring four to six fine spinelets.

The measurements of the marginal plates are as follows :

	Plate No.									
	Supero-marginals.				Infero-marginals.					
	1.	8.	15.	25.	1.	4.	8.	16.	30.	
Larger specimen, length .	2	2·75	2	1·75	1·75	2	2·5	2·25	1·25	mm.
,, ,, breadth	6·5	5·5	5	2	8	7·5	5	3·5	1·25	,,
Smaller specimen, length	2	2·5	2·5	1·5	1·75	2	2	2	1·25	,,
,, ,, breadth	6	5	4	2·5	6	5·5	4	2·5	1·25	,,

The *actinal intermediate plates* bear three rows of four to six papilliform granules and usually a fine spinelet in the centre.

The furrow margin of the *adambulacral plates* is angular, with the apex nearer the proximal end of the first six or seven plates, but coming to lie in the centre of the rest. There are six to eight furrow spines, and on the actinal surface of the plate about twenty papilliform granules from among which spring fine acicular spines, two in number on the first ten plates, a single one on the rest.

Remarks.—The specimens differ from Fisher's description of the type in the following respects : (i) the eighth supero-marginal is the largest, in the type the fifth ; (ii) the infero-marginal spinelets number four to six, while in the type there are only two or three ; (iii) fine spines occur on the actinal intermediate plates, and a second fine spine is found on the proximal adambulacral plates. These are absent from the type (R 45 mm.), and also from the slightly larger specimen (R 53 mm.) described by Döderlein.

Both specimens are considerably larger than previously described examples and the three characters in which they differ may well be due to growth changes. In the remaining features they agree closely with the description of the type.

Paragonaster ctenipes breviradiatus subsp. n. (Pl. II, fig. 6.)

Occurrence :

St. 105, Zanzibar area, 238–293 m., green mud ; 17 specimens.
St. 106, ,, ,, 183–194 m., ,, ,, 46 ,,
St. 153, Maldives, 256–293 m., 1 specimen.

Diagnosis.—Close to *Paragonaster ctenipes* Sladen, but differing in having shorter,

more tapering arms with fewer marginal plates; more granules on the abactinal and supero-marginal plates: two rows of fine tapering spinelets on the first few infero-marginals, fine tapering spinelets on the actinal intermediate plates and a pair of fine tapering spinelets on the proximal adambulacral plates.

Description.—There is very little variation in this collection, and the description is taken from the thirty-one specimens whose major radius measures between 35 and 53 mm.

The top of the first four to seven *carinal plates* is regularly hexagonal, and bears ten to fourteen polygonal central granules enclosed by a ring of nineteen to twenty-four smaller angular granules. The carinal row extends to the tip of the ray, and at the level of the fourth supero-marginal the shape of the plates changes abruptly from polygonal to rectangular. The first rectangular plate is broader than long, and distinctly broader than the plate preceding it; the remainder are square or a little longer than broad. All bear granules similar to those on the supero-marginal plates.

The plates of the *first lateral row* are identical in size and granulation with the carinals, but there are only six to eight of them, ceasing at the level of the fourth supero-marginal plate. The plates of the second lateral row are similar but slightly smaller and reach the third supero-marginal plate. This row bounds an interradial area where the plates, some thirty in all, are rather irregular in size and shape and closely crowded together. Each is armed with six to twelve peripheral and one to six central granules.

The first *supero-marginal plate* is about two-and-a-half times as broad as long. Both dimensions increase up to the fourth or fifth plate, and thence decrease, the breadth rather more rapidly than the length, as is shown in the following table:

	Plate No.				
	1.	4.	8.	16.	24.
Length	1·5	2	1·75	1·25	1 mm.
Breadth	3·5	4·5	3	2·25	0·75 mm.

The surface of the first few plates is closely covered with flat, polygonal, rather large granules arranged in irregular rows; beyond the fifth plate the granules become relatively smaller and the distance between them is greater, amounting to a little more than their radius. There are approximately eight rows of granules on the first plate, ten on the fifth, and ten to twelve on the eighth.

The *infero-marginal plates* correspond to the supero-marginals. The breadth of the first plate is three times the length; the length increases up to the third or fourth plate and thence decreases slowly, while the breadth decreases rather fast. The plates are covered with squamiform granules, among which, on the first few plates, can be made out two rows of three fine spinelets. These spinelets become fewer and very hard to detect on the plates of the arm, but a single one can be made out on six beyond the fifteenth.

The *actinal intermediate plates* are arranged in three chevrons, the innermost containing seven plates reaching the third infero-marginal. Each plate is beset with three rows of four or five papilliform granules, and nearly every one of those in the first two chevrons bears in addition a fine tapering pointed spinelet.

The *adambulacral plates* bear six or seven flattened furrow spines set on an angular margin. The spine at the apex stands with its edge towards the furrow, while two spines on the proximal facet and three or four spines on the distal facet present their flat surfaces

towards the furrow. Three or four elongate granules on the distal and proximal edges of each plate decrease in size as they recede from the furrow and give the impression of being a continuation of the furrow series. Three or four granules and two fine, long, tapering spinelets occupy the centre of the actinal surface of the proximal plates. There is only one spinelet on those plates which lie beyond the limit of the actinal intermediate areas.

Colour.—Paxillar area, brownish red; supero-marginal plates, light coral red; actinal surface, white.

Growth Changes.—The largest member of the collection has R 53 mm., the smallest R 10 mm. Between these extremes the specimens may be conveniently placed in three groups illustrating the changes which accompany growth.

Group.	Number of specimens.	R, mm.	r, mm.	R/r.	Number of SMPs.	Occurrence of spinelets on IMPs., Act. int. plates, Adamb. plates.
I	8	10–12	3·3–4	3	8–11	None.
II	25	18–34	6–10	3–3·6	14–24	Variable. Ranging from complete absence to presence on almost every plate.
III	31	35–53	11–16	3·2–3·8	24–30	Variable in number, but some always present.

Affinities.—The largest specimen is about the same size as Sladen's type of *Paragonaster ctenipes* which is lodged in the British Museum. I have compared the two side by side and find the following differences: (i) the subspecies *breviradiatus* has the arms shorter and more tapering and there are fewer marginal plates; (ii) the central granules of the abactinal plates and all the granules of the supero-marginal plates are more angular, larger, more numerous, and in consequence more closely crowded in *breviradiatus*; (iii) the distribution of fine spinelets on the actinal surface is more abundant than in Sladen's type; there are two rows instead of one on the first few infero-marginals, there is one on many actinal intermediate plates—a condition not found in the type—and there are two on the proximal adambulacral plates, where in the type there is never more than one; (iv) in the type the spines on the adjacent edges of the adambulacral plates are long, and arch over the suture between the plates in such a manner as to suggest a fasciolar pedicellaria. In *breviradiatus* the arrangement is essentially the same, but the spines are shorter and the whole structure is, therefore, much less conspicuous.

An interesting form from the Eastern Archipelago is almost the exact counterpart of *P. ctenipes breviradiatus*, as far as granulation and spinulation is concerned, but differs in having the arms longer than those of *P. ctenipes*. Fisher regards this form as a subspecies and gives it the name *Paragonaster ctenipes hypacanthus*. I have followed his example and created a corresponding subspecies for the present collection of specimens.

Sub-family Goniasterinae.

Genus *Rosaster* Perrier.

In his key to the *Goniasteridæ*, Fisher (1911, p. 158) recognizes both *Nereidaster* and *Rosaster* as separate genera. They are united, and the generic diagnosis revised, in his work on the Philippine Asteroids (1919). Besides the species assigned to the genus in this latter paper, the distribution table below includes *Nymphaster florifer* Alcock, which

Fisher (1911) has tentatively assigned to the genus *Mediaster*, but which I find to be only slightly different from *Rosaster cassidatus* n. sp. described below.

Ocean.	Species.	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic .	*alexandri* (Perrier) .	Perrier, 1884, 1894	8	5	Gulf of Mexico	153–3473 m.	..
		Verrill, 1915	Many		West Indies	151–3473 m.	..
Eastern Archi-pelago	*nannus* Fisher . .	Fisher, 1913	7	3	Philippines	61–98 m.	Soft green mud, coral sand.
		Döderlein, 1924	31	1	Molo Strait	54–90 m.	..
	mammillatus Fisher .	Fisher, 1913	1	1	Philippines	110 m.	Sand, shell, gravel.
	mimicus Fisher . .	,, ,,	4	3	,,	266–452 m.	Dark grey sand.
	symbolicus (Sladen) .	Sladen, 1889	..	2	,, Torres Strait	50–209 m	Green mud. ..
		Fisher, 1919	2	2	Philippines	185–328 m.	Sand.
	bipunctus (Sladen) .	Sladen, 1889	..	1	New Guinea	273 m.	Grey mud.
Indian .	*confinis* (Koehler) .	Koehler, 1910	1	1	Andaman Sea	121 m.	..
	confinis subsp. *timorensis* Döderlein	Döderlein, 1924	1	1	Timor Sea	216 m.	Coral sand.
	florifer (Alcock) . .	Alcock, 1893	..	..	Andaman Sea	236–456 m.	..

Rosaster cassidatus sp. n. (Pl. III, figs. 3 and 6 ; Text-fig. 4.)

Occurrence :

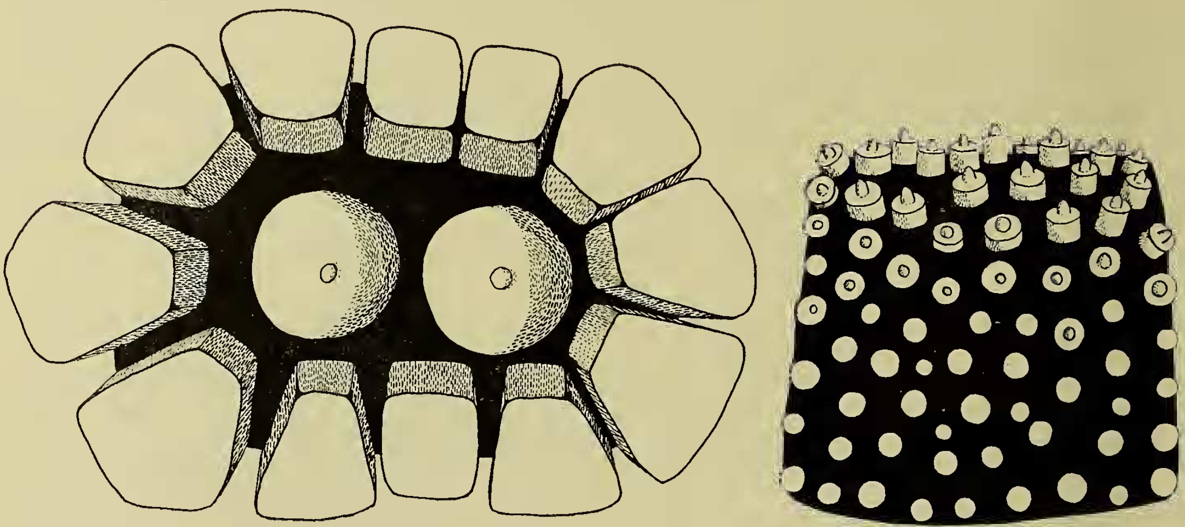
St. 153, Maldives, 256–293 m. ; 57 specimens.

St. 157, ,, 229 m., coral rock ; 1 specimen.

Diagnosis.—R/r 2·9 to 3·1. Disk thin and flat ; arms fine, tapering, rectangular in cross-section ; interbrachial arcs widely rounded. Abactinal plates connected internally by radiating ossicles ; arranged externally in conspicuous radial "petals" each with seven rows of plates, and small triangular interradial areas ; plates of radial areas with eight to twelve angular peripheral and one to three spherical central granules ; plates of interradial areas with six to eight small pointed granules surrounding a single central ; a minute projection on top of most of the granules of interradial plates and on top of central granules of radial plates. Supero-marginal plates twenty to twenty-five ; on proximal half of arm plates separated by a row of carinals, towards tip of arm a few plates usually in contact ; surface beset with cylindrical granules, increasing in size and becoming surmounted by minute projection towards outer edge of abactinal face, becoming pointed towards actinal edge of lateral face. Infero-marginals similar to supero-marginals, but granulation of actinal face coarser. Actinal intermediate plates in four rather irregular chevrons, the innermost reaching the fourth infero-marginal ; plates armed with three or four rows of three or four pointed granules. Adambulacral plates longer than broad, bearing a furrow series of four to eight (usually

five or six) fine radiating flattened spines; on the actinal surface one or two rows of pointed granules, those of the inner row often elongated.

Description.—R 30 to 40 mm. The petaloid radial areas of the *abactinal surface* were very striking in the living specimens, which were beautifully coloured, and they are conspicuous in the preserved material owing to the occurrence of six pores about the base of each component plate. The plates are arranged in seven rows, and all, except those in the carinal row, which are a little broader than long, are regular hexagons. Each has a peripheral series of eight to twelve angular granules and, except for the carinals, which may have two or even three, a single central granule. The central granules consist



A B

Text-fig. 4.—*Rosaster cassidatus* sp. n. A, Carinal plate × 125. B, Supero-marginal plate, abactinal surface × 50.

of a very short stalk and a spherical head, on top of which is a minute projection seen clearly only in dried specimens (Text-fig. 4a).

The *carinal plates* may reach the terminal plate in an uninterrupted series, or, becoming smaller and smaller, may disappear, leaving as many as seven supero-marginals in contact abactinally. More often at the level of about the sixteenth supero-marginal the carinals cease to touch each other and continue as oval plates, each one completely enclosed by four supero-marginals. There may be but two or three of these isolated carinals, or they may persist as far as the last pair of supero-marginal plates. At the level of the sixth supero-marginal the carinal plates are square, with the granules arranged in three rows of three, and on the distal half of the ray the plates are longer than broad. Twelve plates extend to the level of the fourth supero-marginal, and beyond this point two carinals correspond approximately to one supero-marginal.

The first lateral row of plates usually ceases at the level of the sixth supero-marginal, but occasionally isolated plates may be detected for some distance farther down the ray.

In the interradial areas the plates are small and square. They lie in five rows parallel with the radial plates and successive rows contain approximately 9, 7, 4, 3 and 2 plates. Each is beset with six to eight angular peripheral granules, lying about a single one in the centre. A minute projection occurs on top of nearly every one of these granules.

The *supero-marginal plates* form a broad border to the paxillar area, and together with the infero-marginals, a straight vertical or slightly concave side to the disk and arms. The dimensions of plates from a specimen with R 39 mm. are :

	Plate No.			
	1.	4.	8.	16.
Height	1·25	1·25	0·75	0·5 mm.
Length	1·75	2	1·75	1 mm.
Breadth	1·75	1·75	1·25	1 ,,

There are six to eight rows of granules on the surface of the plates, very regularly arranged in some specimens, irregular in others. The granules take the form of small cylinders with the height and diameter approximately equal. Near the inner border of the plate they are of about the same size as the granules on the neighbouring abactinal interradial plates, but towards the outer border of the plate they become larger and are surmounted by a minute projection (Text-fig. 4B). These armed granules extend about half-way down the lateral face of the plate and then give way to very sharp fine spinelets, perhaps 0·25 mm. in length. Two-valved pedicellariæ occur on some of the supero-marginal plates ; they do not, as far as can be made out, occur anywhere else.

The *infero-marginal plates* correspond to the supero-marginals only in the interradius and at the tip of the ray. Their granulation is similar, fine spinelets occur on the lateral face and armed cylindrical granules occur in the neighbourhood of the free border, but on the actinal surface the granules become coarse and pointed.

The *actinal intermediate plates* are irregularly square and well separated from each other. It is possible to make out four chevrons, containing 8 to 10, 5 to 7, 2 to 4, and 1 to 3 plates, as well as one or two odd plates alongside the interradial line. The plates are armed with coarse pointed fluted granules in three or four rows, each row containing three or four granules.

The *adambulacral plates* bear a furrow series of very flattened radiating spines, of which the most proximal is smaller than the rest, which are subequal. The spines present their edges to the furrow, and viewed from the furrow they appear straight-sided and truncate. If the flat surface be examined it is seen that the spines are slightly curved and sometimes a little swollen at the tip. Usually there are five spines on the first few plates ; the number increases to six and not infrequently seven in the neighbourhood of the fifth or sixth plate. Occasionally there are only four spines on the proximal plates ; in one specimen there are eight spines on the distal plates. On the actinal surface of the plate there are commonly two rows of four granules similar to those of the actinal plates. One or two of the granules in the inner row are often elongated, and attain a length equal to a quarter or a third of that of the furrow spines. Many plates, however, bear but a single row, in which case none of the granules are elongated.

The *mouth plates* bear eight or nine furrow spines and, parallel with them on the actinal surface, a row of three to five pointed spines square or triangular in cross-section. Four to six pointed granules stand near the distal border of the plate.

Colour.—" Petals," russet vinaceous ; carinals along the arms, coral red ; abactinal interradial areas, light coral red ; supero-marginals, salmon buff ; actinal surface, white.

Variation.—One specimen with four arms was taken.

Young Forms.—The characters set forth above are those of fifty-two specimens with a major radius of between 30 and 40 mm. Six smaller specimens were caught and the characters in which they differ from the larger are tabulated below.

R, mm.	r, mm.	R/r.	Number of SMPs.	Number of plates in Act. int. chevrons.	Number of furrow spines.	Condition of carinals.
16	6	2·6	11	5, 3, 1	4 to 5	Reaching TP. in continuous series along three arms, in discontinuous series from 8th SMP. along two.
16	6	2·6	11	6, 3, 1	5 to 6	Not reaching TP. In discontinuous series from 4th SMP.
10	4	2·5	11	3, 2	4	Reaching TP. in discontinuous series from 3rd SMP.
13	5	2·6	12	4, 3	4 to 5	
15	5	3	11	4, 3	4 to 5	
13	5	2·6	9	4, 3	4 to 5	Reaching TP. in continuous series.

Affinities.—This species may be distinguished at once from *R. alexandri* (Perrier), *R. nannus* Fisher, *R. confinis* (Koehler), *R. mimicus* Fisher and *R. bipunctus* (Sladen) by the line of carinal plates between the supero-marginals. It differs from *R. mammillatus* Fisher in lacking any tubercular structure on the supero-marginal plates. *R. symbolicus* (Sladen) has more numerous abactinal granules (twenty-two to twenty-five peripheral and seven to eight central) and more furrow spines (ten). *R. cassidatus* is very close to the starfish named *Nymphaster florifer* by Alcock, a species which Fisher suggests may belong to the genus *Mediaster*.

From Alcock's description two differences emerge: (i) the supero-marginals of *florifer* never meet, and (ii) the furrow spines number seven to eight. In the present series of specimens it is exceptional for no supero-marginals to meet, though this condition is occasionally found, and only one specimen out of fifty-eight has as many as eight furrow spines, the usual number being five or six. Through the kindness of the Indian Museum I have been able to examine two small specimens of *N. florifer* from their collection. They have the following characters:

R, mm.	r, mm.	R/r.	Number of SMPs.	Number of plates in Act. int. chevrons.	Number of furrow spines.	Condition of carinals.
22	7	3	15	7, 4, 2	6 to 7	Reaching TP. in continuous series.
22	8	3	16	7, 4, 2	6 to 7	Ditto.

These figures bear out the difference noted in the description, and a third point of difference is apparent on comparison. The supero-marginal plates are distinctly narrower in the Indian Museum specimens and are longer than broad almost to the tip of the ray.

The differences between the two species are thus slight, but, while doubt exists as to the true generic position of *florifer*, I have deemed it the safer course to create a new species for the present series of examples. Their position in the genus *Rosaster* has been confirmed by an examination of the internal plates.

Genus *Mediaster* Stimpson.

The first adequate account of the genus is given by Verrill (1899, p. 178), and a further revision has been made by Fisher (1911, p. 196). The list of species in the following distribution table is taken from the latter paper, and includes the three species (*M. pedicellaris*, *M. agassizii* and *M. florifer*) whose position in the genus has still to be confirmed, though it is believed that *M. florifer* will ultimately find a resting-place in the genus *Rosaster* (see p. 368). The table also includes *M. sladeni* Benham (1909), a species not referred to by Fisher, and three species described since 1911.

Ocean.	Species. (Synonyms in brackets.)	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic .	*pedicellaris* (Perrier) .	Perrier, 1884	5	3	West Indies	200–320 m.	Fine black sand; hard ground.
		Verrill, 1915	1	1	,, ,,	217–324 m.	..
	bairdii (Verrill) . .	,, 1899	..	5	Coast of U.S.A.	860–1313 m.	..
	(*stellatus* Perrier) .	Perrier, 1896	..	1	Newfoundland	1267 m.	Sand and stones.
		Grieg, 1932	5	1	,,	1100 m.	..
	agassizii Verrill . .	Verrill, 1899	..	..	West Indies	..	..
Pacific .	*æqualis* Stimpson .	Stimpson, 1857	..	..	California	50 m.	..
		Fisher, 1911	231	60	Alaska to California	16–300 m.	Various.
		Bush, 1918	"Rather numerous"		Puget Sound	..	..
		Ulrey, 1918	..	32	S. California	36–288 m.	Various.
	tenellus Fisher . .	Fisher, 1904	..	..	,,	816–932 m.	..
	transfuga Ludwig .	Ludwig, 1905	8	1	Gulf of Panama	902 m.	Green mud.
	brachiatus Goto . .	Goto, 1914	..	2	Japan	493–1000 m.	..
Indo-Pacific	*præstans* Livingstone .	Livingstone, 1933	..	..	Great Barrier Reef	..	..
	sladeni Benham . .	Benham, 1909	..	11	New Zealand	45–55 m.	Shell, gravel.
	arcuatus (Sladen) .	Sladen, 1889	1	1	Japan	630 m.	Green mud.
		Goto, 1914	3	..	,,	877–1023 m.	,, ,,
		Alcock, 1893	1	1	Andaman Sea	500 m.	,, ,,
	ornatus Fisher . .	Fisher, 1906	35	9	Hawaii	520–1155 m.	Sand, various.
		,, 1919	3	2	Philippines	745–877 m.	Green mud and coral.
		Döderlein, 1924	1	1	New Guinea	1633 m.	Coral.
		Koehler, 1909	3	1	Gulf of Oman	898 m.	
	florifer (Alcock) .	Alcock, 1893	..	..	Andaman Sea	236–456 m.	..
	capensis H. L. Clark .	Clark, 1923	4	2	Cape of Good Hope	36–158 m.	Green mud and sand.
		Mortensen, 1933	2	1	,, ,,	168 m.	..
	capensis var. *durbanensis* Mortensen	,, ,,	1	1	,, ,,	405 m.	..

Mediaster ornatus Fisher.

Mediaster ornatus, Fisher, 1906, p. 1046, pl. xvi, figs. 3, 3*a*, pl. xx, figs. 1 and 2 ; Koehler, 1909, p. 78 pl. x, fig. 4 ; Fisher, 1919, p. 256 ; Döderlein, 1924, p. 52, pl. xiv, figs. 6 and 6*a*.

Occurrence :

St. 159, Maldives, 914–1463 m. ; 1 specimen.

Distribution.—Hawaii, Gulf of Oman, Philippines, New Guinea ; Maldives.

Remarks.—The species has been thoroughly described and figured and I have no hesitation in referring to it a specimen with the following characters : R 40 mm., r 16 mm., R/r 2·5 ; supero-marginals twenty-two ; breadth of ray at level of fourth supero-marginal, 10 mm., eighth supero-marginal, 6 mm., twelfth supero-marginal, 4 mm., and sixteenth supero-marginal, 2·5 mm. The abactinal plates are arranged in regular radial series. The carinals are the largest and have about eighteen peripheral and twelve central granules, the latter in three rows. The actinal intermediate plates lie in regular chevrons, of which the innermost reaches the ninth infero-marginal. In successive chevrons there are some 20, 16, 11, 8, 6, 5 and 3 plates. The adambulacral plates have six to eight furrow spines, and actinally an outer row of five granules and an inner row of five spines, more robust and shorter than the furrow spines.

The number of furrow spines is evidently liable to some variation, for the type has eight, Koehler's examples five, Fisher's Philippine examples five to seven, and Döderlein's examples eight to eleven. The present specimen resembles the type in this character, while agreeing with Döderlein's material in the rather large number of granules on the abactinal plates.

Mediaster murrayi sp. n. (Pl. III, figs. 1, 2 and 4 ; Text-fig. 5.)

Occurrence :

St. 107, Zanzibar area, 421–457 m. ; 5 specimens.
St. 109, ,, ,, 640 m., light grey mud ; 43 specimens.
St. 123, ,, ,, 256–366 m., green mud, sand, rock ; 9 specimens.

Diagnosis.—R/r 2·4 to 2·8. Abactinal surface inflated ; actinal surface flat ; arms tapering somewhat broadly at base, more sharply from a point about midway down, tip rounded ; interbrachial arcs rather flattened. Abactinal plates in regular radial series ; hexagonal, the carinals broader than long, with twenty to thirty truncate peripheral granules and six to twelve hemispherical central granules in one, two or three regular rows. Supero-marginals confined to side wall of disk but encroaching gradually on to abactinal surface of arms ; with regular rows of granules and one or two pedicellariæ. Infero-marginals alternating with supero-marginals except interradially, granulation coarser. Actinal intermediate areas small for the genus ; plates arranged in about six chevrons, the innermost reaching the fifth or sixth infero-marginal. Adambulacral plates with seven to nine delicate radiating flattened furrow spines, and actinally two series, an inner of three coarse spines and two granules, and an outer of four or five granules.

Description.—R 30 to 47 mm., r 11 to 17 mm. The table below, giving the breadth of the arm at the level of successive marginal plates, is from a specimen with R 40 mm. The rest of the description is based on all the specimens.

	Plate No.			
	4.	8.	12.	16.
Breadth of arm . .	10 .	6 .	5 .	3·5 mm.

The radial areas of the *abactinal surface* comprise nine regular rows of hexagonal plates. The carinals are two to three times as broad as long, while of the plates in the four rows on either side, the first differ only in being scarcely longer than broad and the rest show a progressive diminution of size as the interradial areas are approached. Each plate in the radial area has six papulæ around it, one opposite each corner. The interradial areas are paved with four-sided, closely crowded plates.

The carinal plates have round the edge twenty to thirty radiating subtruncate granules, and in the centre six to twelve granules which are well spaced and arranged in regular rows, of which there is occasionally only one, usually two, and less frequently three. The interradial plates have eight to ten peripheral granules round a single one in the centre. Most of the plates of the radial areas, and many of those in the interradial areas as well, bear a two-valved pedicellaria of rather simple form (Text-fig. 5A).

The carinals usually reach the terminal plate. The first lateral row persists for a distance which is very variable and may be different on the two sides of one arm. They usually disappear in the neighbourhood of the seventeenth supero-marginal but in some specimens they appear to cease abruptly at the level of the twelfth. In this case the carinals which, from the level of the sixth supero-marginal, show a gradual transition from a hexagonal to a square shape, suddenly become rectangular, with the breadth quite three times the length. This effect is almost certainly due to fusion of the carinal and first lateral plates.

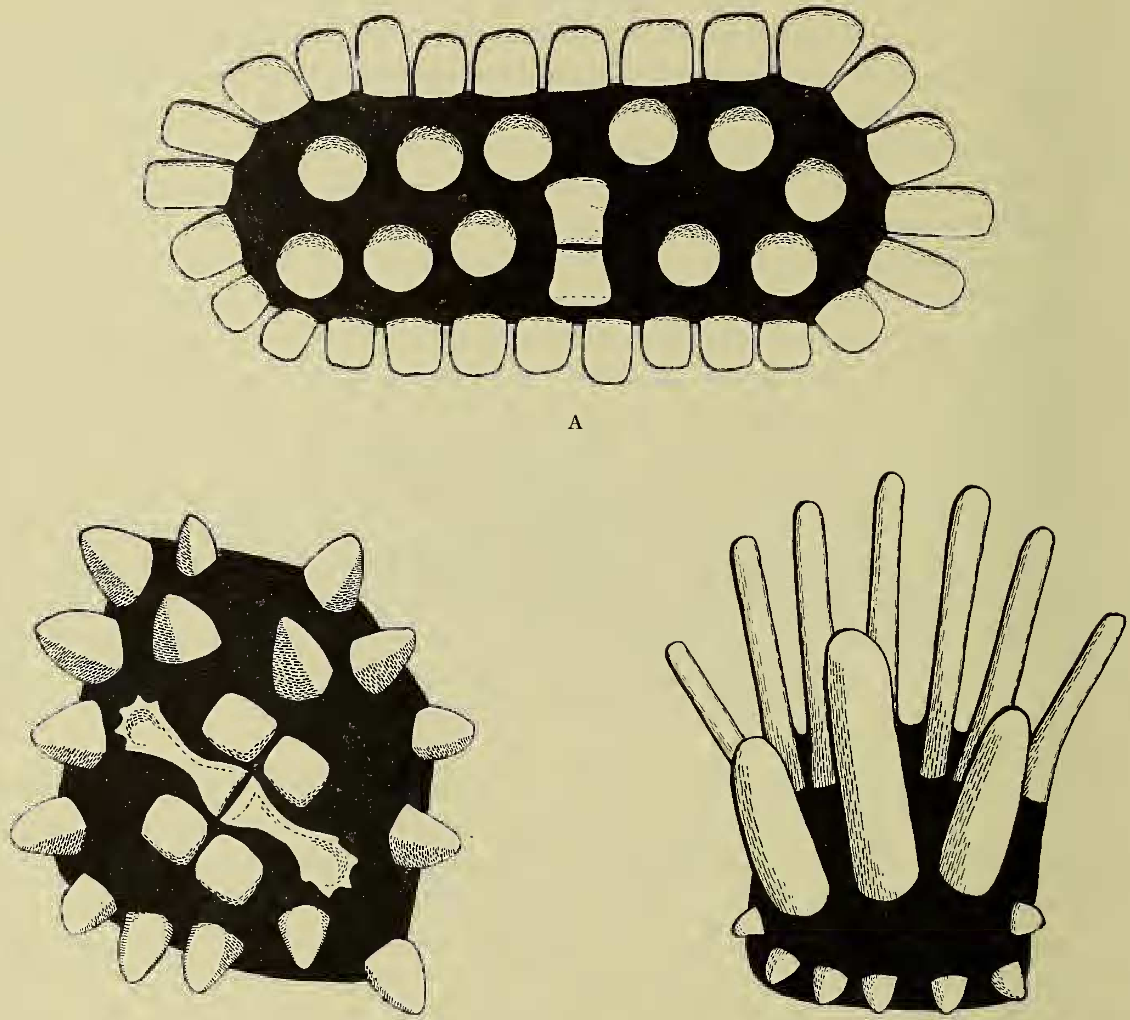
The *supero-marginal plates* number twenty-one to twenty-four. They are confined to the side of the disk and base of the ray, but at about the seventh, or in some of the larger specimens not till the twelfth plate, they begin to encroach on to the abactinal surface, and this continues to the tip of the ray, where the last pair may be in contact. The first plates are higher than long but the length increases somewhat abruptly, and from the third or fourth plate outwards they are square. Both dimensions decrease equally till the last eight or ten plates, where the height is again greater than the length. The plates are beset with small well-spaced hemispherical granules in regular rows, of which there are six on the first plate and eight or nine on the fifth. Each plate bears one, occasionally two pedicellariæ.

The *infero-marginal plates* usually alternate with the supero-marginals, except interradially. Their granules are coarser and more pointed than those of the supero-marginals. The plates encroach on to the actinal surface of the disk but are confined to the side walls of the rays.

The *actinal intermediate areas* are paved with numerous quadrangular plates arranged in about six chevrons, of which the innermost reaches the fifth or sixth infero-marginal. A typical arrangement is 13, 9, 7, 4, 2, 1 plates in successive chevrons. The plates are well spaced from one another, and each is surmounted by three or four rows of three or

four pointed or rounded granules (Text-fig. 5B). Most of the plates of the inner chevron and a certain number of the remainder bear pedicellariæ.

The pedicellariæ of the marginal and actinal plates consist of two long spatulate jaws sunk in a slight depression. These jaws may lie isolated, but usually two or four granules are situated on the edge of the pit and slightly overlie it. There is no indication that these granules are mobile, but the whole complex suggests a multivalvular pedicellaria.



A

B C

Text-fig. 5.—*Mediaster murrayi* sp. n. A, Carinal plate × 125; B, Actinal intermediate plate × 125; C, Adambulacral plate × 125.

The *adambulacral plates* (Text-fig. 5C) bear on a uniformly rounded furrow margin seven to nine delicate flattened round-tipped radiating spines. On the actinal surface there is an outer series of four or five granules and an inner series, which is usually made up of two granules at the edges and three spines in the centre. The middle spine is flattened, rather pointed, twice as thick and nearly as long as the furrow spines. The other two may be as long as this middle spine or considerably shorter.

The *mouth plates* have twelve furrow spines. On the actinal surface there are two

series, one consisting of three granules distally and three coarse spines proximally, parallel with the furrow, the other consisting of five or six granules, parallel with the suture between the two plates.

Internal radiating ossicles connecting the abactinal plates and very small superambulacral ossicles are present.

Colour.—The colour was the same all over the body, and in the forty-three specimens from St. 109 it varied from coral pink to light coral red or coral red.

Variation.—A single specimen from St. 109 has six arms, but in the remainder of its features agrees with the rest of the collection.

For the most part there is little variation, and an account of such as does exist is incorporated in the description. There is, however, one extremely interesting feature, namely, the tendency for the abactinal plates to fuse. In about ten specimens the carinals fuse with the first lateral plates at the level of the twelfth supero-marginal plate. In two specimens from St. 109 the fusion begins at the base of the ray, level with the fifth supero-marginal. There are never more than two plates fused together, but while a carinal plate only fuses with a first lateral, the plates in this row may fuse with each other, as well as with the plates on either side. The most extreme condition is found in a specimen from St. 123. Here the carinals fuse at the base of the ray with the laterals on both sides, and great boomerang-shaped plates, which distally become rectangular, are formed.

This tendency to fuse may lead to a great irregularity in the plates of the ray, and had a specimen with this feature turned up alone it might well have been made the type of a new genus.

Affinities.—The species is distinct and, judging from descriptions, not closely related to any other. Its salient characters are the broad carinals, supero-marginals confined to side wall of disk, relatively small actinal intermediate areas and relatively numerous long furrow spines.

Genus *Nymphaster* Sladen.

Fisher (1919, p. 263) discusses the synonymy of this genus.

Thirty species have been ascribed by various authors to this genus, but of these six have been referred to other genera, namely :

Species.	Author.	New genus.	Author of change.
Nymphaster symbolicus	Sladen, 1889	*Nereidaster*	Verrill, 1899.
N. bipunctus	Sladen, 1889	*Rosaster*	Fisher, 1913.
Dorigona longimana	Möbius, 1859	*Iconaster*	Bell, 1884.
D. pentaphylla	Alcock, 1893	*Iconaster*	Koehler, 1909.
		Lithosoma	Fisher, 1919.
D. confinis	Koehler, 1910	*Rosaster*	,, 1913.
Nymphaster florifer	Alcock, 1893	*Mediaster*	,, 1911.

The distribution of the remaining species is shown in the accompanying table. Many of the species are now regarded as synonyms. Those in the Atlantic are discussed by Verrill (1899) and Farran (1913), and those in the Indian Ocean are discussed below.

Ocean.	Species. (Synonyms in brackets.)	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic	*arenata* (Perrier)	Perrier, 1884	9	8	Gulf of Mexico	298–1605 m.	Fine sand and mud.
		„ 1894	54	15	Coast of Morocco	530–1635 m.	Mud.
		Koehler, 1895	1	1	Coast of France	560–1400 m.	..
		„ 1909*a*	"Very frequent"		N. Atlantic	820–1440 m.	Hard ground; sandy mud; fine sand.
		Farran, 1913	126	12	W. coast of Ireland	379–1659 m.	Various.
		Grieg, 1932	3	1	Coast of Spain	535 m.	Yellow sand.
	(*protentus* Sladen)	Sladen, 1889	1	1	SW of Canary Is.	2787 m.	Hard ground.
		Bell, 1889	..	5	SW of Ireland	..	..
	(*subspinosus* Perrier)	Perrier, 1884	6	2	Gulf of Mexico	761–1342 m.	..
		Koehler, 1895	1	1	Coast of France	400–500 m.	..
	(*prehensilis* Perrier)	Perrier, 1884	..	..	Coast of Morocco	..	..
	(*jacqueti* Perrier)	„ 1894	36	8	Coast of Spain	550–1238 m.	..
		Koehler, 1895	5	2	Coast of France	960 m.	..
	ternalis (Perrier)	Perrier, 1884	2	2	Gulf of Mexico	761–1342 m.	..
	albidus Sladen	Sladen, 1889	1	1	Off Cape Verde	..	..
	basilicus Sladen	„ „	1	1	Coast of Brazil	2193 m.	Red mud.
Pacific	*diomedeæ* Ludwig	Ludwig, 1905	53	4	Galapagos and Cocos Is.	702–1812 m.	Globigerina ooze and sand.
	pentagonus H. L. Clark	Clark, 1916	1	1	Great Australian Bight	450–800 m.	..
Eastern Archipelago	*euryplax* Fisher	Fisher, 1913, 1919	1	1	Mindanao Sea	319 m.	Globigerina ooze.
	dyscritus Fisher	„ „ „	2	2	Philippine Is.	394–402 m.	Green mud; fine sand and broken shells.
	mucronatus Fisher	„ „ „	1	1	Balayan Bay	365 m.	..
	moluccanus Fisher	„ „ „	2	2	Molucca Is.	400 m.	Grey mud; grey mud and fine sand.
	arthrocnemis Fisher	„ „ „	3	2	Celebes Is.	1050–1260 m.	Green mud.
	meseres Fisher	„ „ „	2	2	Philippine Is.	700 m.	Fine sand.
	habrotatus Fisher	„ „ „	5	3	„ „	612–1324 m.	Green mud, coral.
	atopus Fisher	„ „ „	3	1	Sulu Sea	2000 m.	Grey mud.
	leptodomus Fisher	„ „ „	11	2	Luzon	396 m.	Green mud.
Eastern Archipelago to Indian	*mœbii* (Studer)	Studer, 1884	..	..	NW coast of Australia	350 m.	..
		Döderlein, 1924	..	..	Eastern Archipelago	450–462 m.	Globigerina ooze; grey mud.
	(*ternalis* Koehler)	Koehler, 1909	4	4	Bay of Bengal, W. of Ceylon Arabian Sea	1097–2504 m.	..
	(*belli* Koehler)	„ „	1	1	Andaman Is.	456 m.	..
	(*ludwigi* Koehler)	„ „	..	..	Laccadive Sea	2504 m.	Coral mud.
	nora Alcock	Alcock, 1893	..	..	Andaman Sea	882 m.	..

Nymphaster mœbii (Studer). (Pl. IV, figs. 1 to 10 ; Text-figs. 6, 7 and 8.)

Pentagonaster mœbii, Studer, 1884, p. 30.
Nymphaster protentus, Alcock, 1893, p. 95.
Nymphaster basilicus, Alcock, 1893, p. 95.
Dorigona ternalis, Koehler, 1909, p. 54, pl. viii, figs. 5 and 6.
Dorigona ludwigi, Koehler, 1909, p. 61, pl. ix, figs. 5 and 6.
Dorigona belli, Koehler, 1909, p. 58, pl. viii, figs. 2, 3 and 4.
Nymphaster mœbii, Döderlein, 1924, p. 55, pl. xiv, figs. 2 and 2*a* ; pl. xv, fig. 1.

Occurrence :

St. 105, Zanzibar area, 238–293 m., green mud :	2	specimens.
St. 108, ,, ,, 786 m., grey mud :	3	,,
St. 109, ,, ,, 640 m., ,, ,,	1	specimen.
St. 110, ,, ,, 347–384 m., grey green mud and sand :	3	specimens.
St. 115, ,, ,, 640–685 m. :	3	,,
St. 122, ,, ,, 732 m., grey green mud ;	43	,,
St. 143, Maldives, 797 m., grey sand :	9	,,
St. 145, Kardiva Channel, 494 m., green mud and sand ;	2	,,
St. 184, Gulf of Aden, 1270 m., green mud :	6	,,

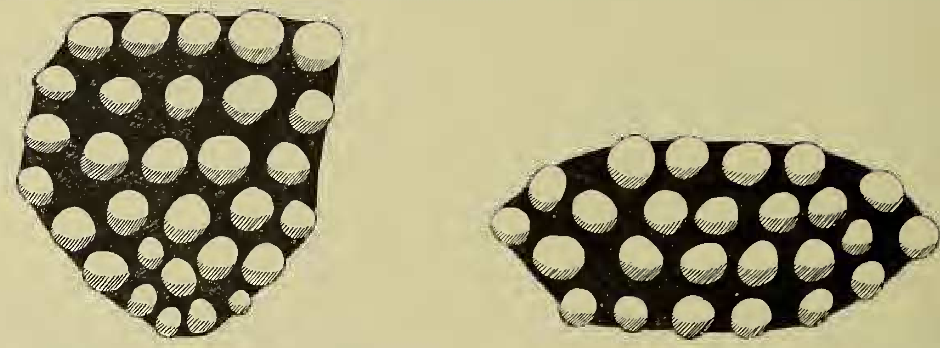
Remarks.—This collection of seventy-two specimens contains forms which, if taken alone, might be referred to six distinct species, viz. *N. mœbii* (Studer), *N. ludwigi* (Koehler), *N. belli* (Koehler) and *N. alcocki* (? nom. nud., *see* p. 380), and perhaps two new species. It is found, however, that between these forms occur others which are intermediate in character, and the specific distinctions of previous authors, based on a small number of specimens, break down. The collection does tend to fall into groups, each group for the most part coming from a different area, but the characters of the groups overlap, and it is believed therefore that the present series of specimens, together with the previously known species in the synonymy list above, belong really to a single variable species. This view is strengthened by a study of the many changes which the names of the previous species have undergone. The first examples collected in the Indian Ocean were identified by Alcock as *N. protentus* Sladen and *N. basilicus* Sladen, both forms known only from the Atlantic. Koehler re-examined the material and decided that Alcock was mistaken. From among the specimens he described two new species, *N. ludwigi* and *N. belli*, and identified others as *N. ternalis* Perrier, another Atlantic form. Döderlein regards Koehler's *ternalis* as identical with the Australian species *N. mœbii* (Studer).

Of the present collection the forty-three specimens taken in the Zanzibar area at St. 122 (Pl. IV, figs. 1, 5, 10, cat. no. 98) resemble most closely the type of *N. mœbii*, and it is therefore on the eleven largest members of this collection (r 18 to 25 mm.) that the diagnosis and description below are based. Twenty-four of the specimens have r 8 to 12 mm. and the characters of these smaller examples are compared with those of the larger. Finally the characters of four lines of variation found in the collection are compared with the diagnosis of the typical form, and reasons why these are not regarded as distinct species are given.

For each specimen variable features such as the number and size of the plates, the number and character of spines or granules on different plates and the number of pedicellariæ on different areas have been recorded in a manuscript, which, since it is too cumbrous to print here, has been deposited with the British Museum (Natural History).

This makes it necessary that each specimen bears a catalogue number, and these numbers are referred to in the following discussion.

Diagnosis.—R/r 3·8–4·4. Disk with abactinal and actinal interradial areas below the level of the marginal plates. Rays long tapering, rectangular or rounded abactinally in cross-section. Abactinal surface with seven columns of plates down each radius; a number of small irregular closely crowded plates in each interradius; carinal plates fourteen to eighteen in number, usually hexagonal, slightly broader than long, sometimes round, square or irregular, the distal two or three often compressed and twice as broad as long, proximal plates with thirty to fifty round granules; three rows of smaller hexagonal



A B

Text-fig. 6.*—*Nymphaster mœbii* (Studer). A, 3rd carinal plate × 50 (No. 100*d*; St. 184); B, 2nd carinal plate × 50 (same specimen).

plates, with similar granulation, on each side of carinal row; pedicellariæ on a variable number of abactinal plates. Supero-marginals in contact down arms; plates bounding disk with sloping abactinal surface, those along arms with abactinal and lateral faces at right-angles or sometimes joining in a widely rounded curve; with about twelve rows of hemispherical granules; a variable number of plates with pedicellariæ. Infero-marginals similar to supero-marginals. Actinal intermediate plates in four chevrons; plates with four or five rows of large round or pointed granules; pedicellariæ on some or many plates. Adambulacral plates with palmate furrow series of compressed spines; first plate with seven spines, number increasing on subsequent plates till all beyond about the tenth bear eleven spines; actinal surface with one to three regular or irregular rows of conical or hemispherical granules, inner row sometimes elongate up to half length of furrow spines; on most plates some of the granules arranged to form a two-, three-, or four-jawed pedicellaria. Mouth plates with ten or eleven furrow spines; on actinal surface nine to fifteen granules, of which two or three nearest the inner angle elongated and as long as furrow spines.

Description.—R 54–112 mm., r 13–25 mm. On the *abactinal surface* the interradial areas are sunk below the level of the supero-marginal plates, and are paved with irregular or square plates closely crowded together. In the radial areas there is a carinal row of fourteen to eighteen plates, with three rows of lateral plates on either side. The larger plates near the proximal end of the carinal row have thirty to fifty granules, and the corresponding plates of the lateral rows sixteen to thirty-four. The granules are hemispherical, and usually about half the number are set round the edge and half are

* The figure is of plates from one of the specimens from the Gulf of Aden. The granules are fewer in number than, but otherwise similar to, those of typical specimens from the Zanzibar area.

irregularly arranged in the centre, but there is no difference in form between the granules of the two groups (Text-fig. 6A). In shape the carinals are usually hexagonal, a little broader than long, but they may be round, square or irregular, and at the outer end of the row two or three are compressed and the breadth is twice the length. The granules on the latter plates number about thirty, and those in the centre are arranged in two regular rows (Text-fig. 6B). In most specimens there are only two or three such carinals, but in others they are more numerous, and in a few examples almost every plate in the carinal row is of this shape. It is noteworthy that Koehler regards this character as diagnostic of *N. belli*. The lateral plates are regularly hexagonal, but towards the edge of the disk they become small and irregular in shape. In some specimens there is a two-jawed pedicellaria on almost every radial and interradial plate, and in others pedicellariæ are absent from the abactinal surface.

There are thirty to forty *supero-marginal plates*. Eight or ten bound the paxillar area of the disk and the remainder are in contact with their opposites down the length of the ray. In transverse section the arm is usually rectangular, sometimes the sides are slightly concave, and in some specimens the lateral and abactinal faces of the supero-marginal plates join at a widely rounded curve instead of a right-angle so that the arm has a D-shaped section. Seen in surface view the plates are usually flat, but sometimes they are a little convex, and sometimes, particularly on the specimens with the rounded arms, they are slightly concave.

The first three or four plates are much broader than high, as the abactinal surface slopes downwards to the outer edge. Along the arms the abactinal surface of the plates is horizontal and the breadth is only a little greater than the height. The following measurements are from a specimen with r 19 mm. (No. 98, 11).

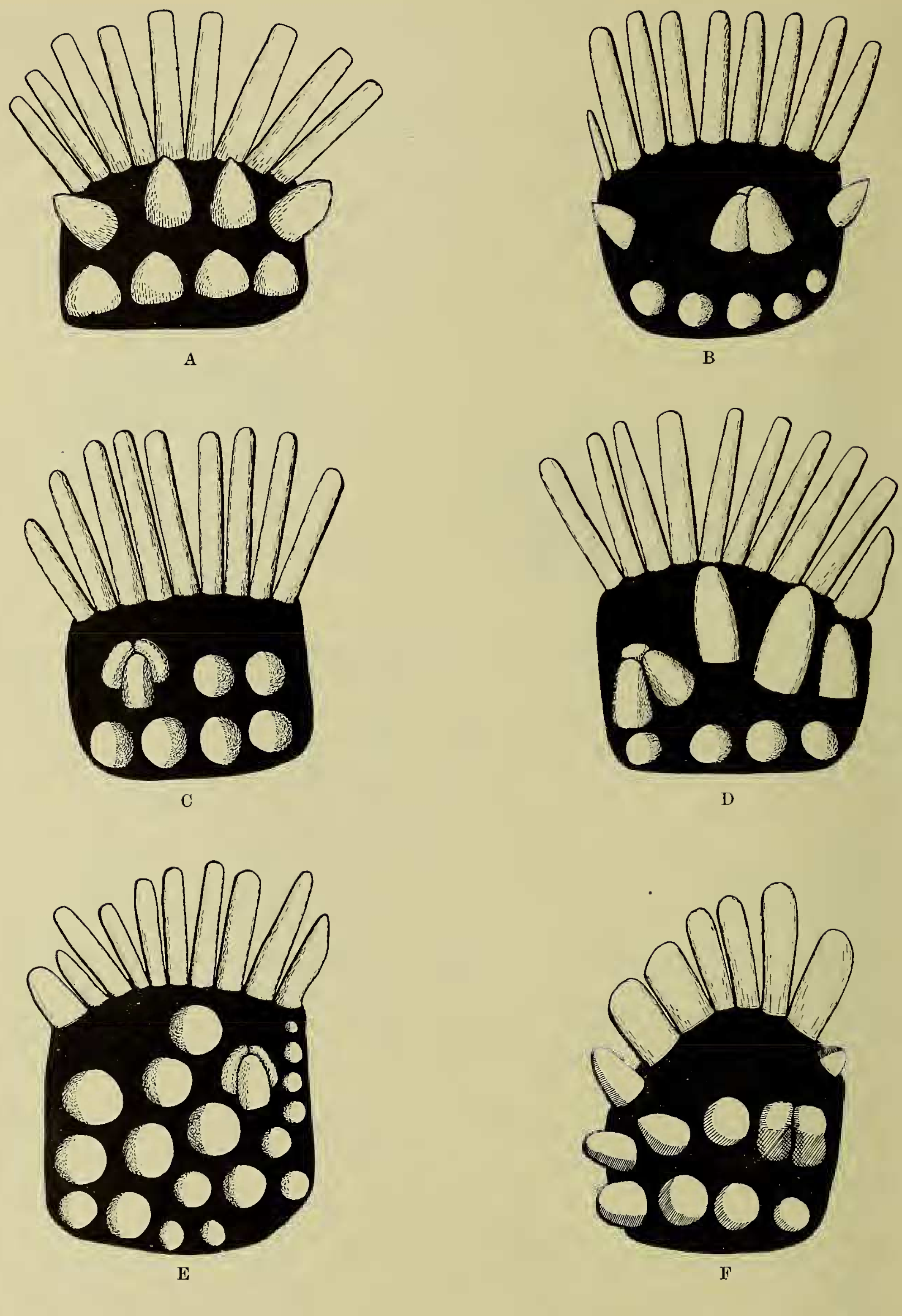
	Plate No. 1.	6.	12.	24.	
Height	1	2	1·5	1·25	mm.
Breadth	3·5	3	2·0	1·25	,,
Length	2·5	3	2·75	1·75	,,

The plates are covered with large hemispherical granules, arranged in about twelve irregular rows. One or two bivalved pedicellariæ are found on nearly every plate in some specimens, while in others they are almost absent. Usually they are sunk in small pits and lie flush with the surface of the plate ; in three examples they are lodged in conspicuous swellings.

The *infero-marginal plates* correspond to the supero-marginals, and resemble them both in the distribution of pedicellariæ and in granulation. The following measurements are taken from specimen No. 98, 11 :

	Plate No. 1.	5.	10.	20.	
Height	1·5	1·5	1·25	0·75	mm.
Breadth	3·75	2·5	1·25	0·5	,,
Length	3	2·75	2·25	1·75	,,

The *actinal intermediate areas* are paved with four chevrons containing successively some 14, 10, 5 and 2 plates. The innermost chevron extends to the fifth or sixth infero-marginal plate. The surface of each plate bears four or five rows of conical granules which



Text-fig. 7.—*Nymphaster mœbii* (Studer). A, 5th adambulacral plate × 33 (No. 95 ; St. 145) ; B, 6th adambulacral plate × 33 (same specimen) ; C, 6th adambulacral plate × 33 (No. 20 ; St. 109) ; D, 7th adambulacral plate × 33 (No. 98, 17 ; St. 122) ; E, 17th adambulacral plate × 33 (No. 40*c* ; St. 108) ; F, 8th adambulacral plate × 33 (No. 100*a* ; St. 184).

may be pointed or rounded at the tip. Some specimens have no pedicellariæ; the majority have between four and twelve, and a few have much larger numbers, the highest being sixty-five. Except in three specimens the pedicellariæ occur only on the plates of the innermost chevron.

The *adambulacral plates* bear furrow spines arranged in a palmate series, with the lateral spines slightly shorter than those in the centre (Text-fig. 7D). Seen from below the spines are straight-sided and truncate at the tip; seen from the side they are tapering and slightly curved. The plate next to the mouth bears seven spines and the number increases on subsequent plates, till, from about the tenth outwards, every plate is armed with eleven spines. The arrangement of the furrow series of spines remains remarkably constant throughout the whole range of specimens; the actinal armature of the adambulacral plates is, on the other hand, extraordinarily variable. A typical plate has two rows of four conical granules, the inner a trifle longer than the outer. The following deviations from this are found: (i) The number of granules may be as low as four or as high as twenty, and according to their number the granules are arranged in one, two or three regular rows, with intermediate stages where the arrangement is less regular. In any one specimen the number of granules is approximately the same for each plate. Intermediate specimens, however, indicate that there is no justification for separating examples with two rows of granules from those with three. (ii) Usually one row of granules is modified to form a two-, three-, or four-jawed pedicellaria. The pedicellariæ may occur on every plate or may be entirely absent. (iii) Sometimes the inner row of granules is slightly elongate. It is possible to trace a series up to the extreme form represented in Text-fig. 7D, where the inner row is definitely spiniform, flattened, and over half as long as the furrow spines. Text-fig. 7 A–F illustrates the different arrangements of the armature of the adambulacral plates. They are taken from specimens in all the lines of variation, but it is found that no separation at all can be effected on this character.

The *mouth plates* are armed with a furrow series of ten or eleven spines similar to those of the adambulacral plates, except for the first two or three, which in transverse section are wedge-shaped instead of rectangular. On the actinal surface some nine to fifteen granules are rather variable in arrangement. There are always two rows, one parallel with the suture between adjacent plates, the other parallel with the suture separating the first adambulacral plate; and there are some granules in the centre, a few of which may form a straight line lying parallel with the furrow spines. The granules are low near the distal end of the plate, but as the mouth angle is approached they show a slight increase in length. Two or three in the corner nearest the mouth are definitely spiniform, wedge-shaped, and nearly as long as the furrow spines.

SMALLER FORMS.—Twenty-four specimens with a minor radius of between 8 and 12 mm. throw light on the growth changes. Their characters are: R/r 3·7 to 4·4; adambulacral plates with seven to eleven furrow spines and one or two rows of actinal granules; mouth plates with seven to eleven furrow spines and four to twelve actinal granules; supero-marginal plates eighteen to twenty-six in number, six to eight bounding the paxillar area; carinal plates seven to nine in number, granules ten to twenty-eight, the most usual arrangement being twelve peripheral and six central; actinal intermediate areas made up of four chevrons containing usually 7, 4, 2 and 1 plates successively.

Thus, compared with the larger forms the smaller forms have the same R/r ratio, and their mouth plates and adambulacral plates show only a very slight tendency to bear

fewer granules. On the other hand the total number of supero-marginal, carinal and actinal intermediate plates is definitely smaller.

Remarks on Synonymy.—The forms just described are believed to conform with the type of *N. mœbii* (Studer). *N. ternalis* (Koehler) is a synonym according to Döderlein, and the foregoing description also embraces *N. ludwigi* (Koehler), which was separated on the following characters, shown above to be quite unreliable : (i) actinal adambulacral granules in two rows in *N. ludwigi*, in three rows in *N. ternalis* ; (ii) pedicellariæ absent from adambulacral plates in *N. ludwigi*, present in *N. ternalis*.

Variations.—The following four variations differ from the typical form, and might have received specific recognition but for the presence of examples intermediate in character.

Type A.—Pl. IV, figs. 2 and 8, St. 184, Gulf of Aden, 6 specimens, Cat. no. 100 a–f.

The extreme member of the series (No. 100 f) has the following characters : The supero-marginal plates are tumid ; the granules of the carinal plates are fewer in number than in the type ; the adambulacral furrow spines are very short (Text-fig. 7F) ; the actinal surface of the mouth plates is covered by granules which are numerous, round and very low, and not elongated near the mouth angle.

The accompanying table shows that the specimens fall into a series progressively approaching the typical form in character :

Cat. No.	r, mm.	Supero-marginal plates.	Armature of actinal surface of mouth plates.	Adambulacral furrow spines.	Number of carinal granules.
100f	18	Tumid	Papilliform	Very short	29
100c	20	,,	,,	Short	25
100d	20	,,	,,	,,	36
100b	21	Slightly tumid	Slightly elongate and rounded	,,	18
100a	22	,, ,,	Ditto.	,,	26
100e	19	,, ,,	,,	Resembling those of type	23

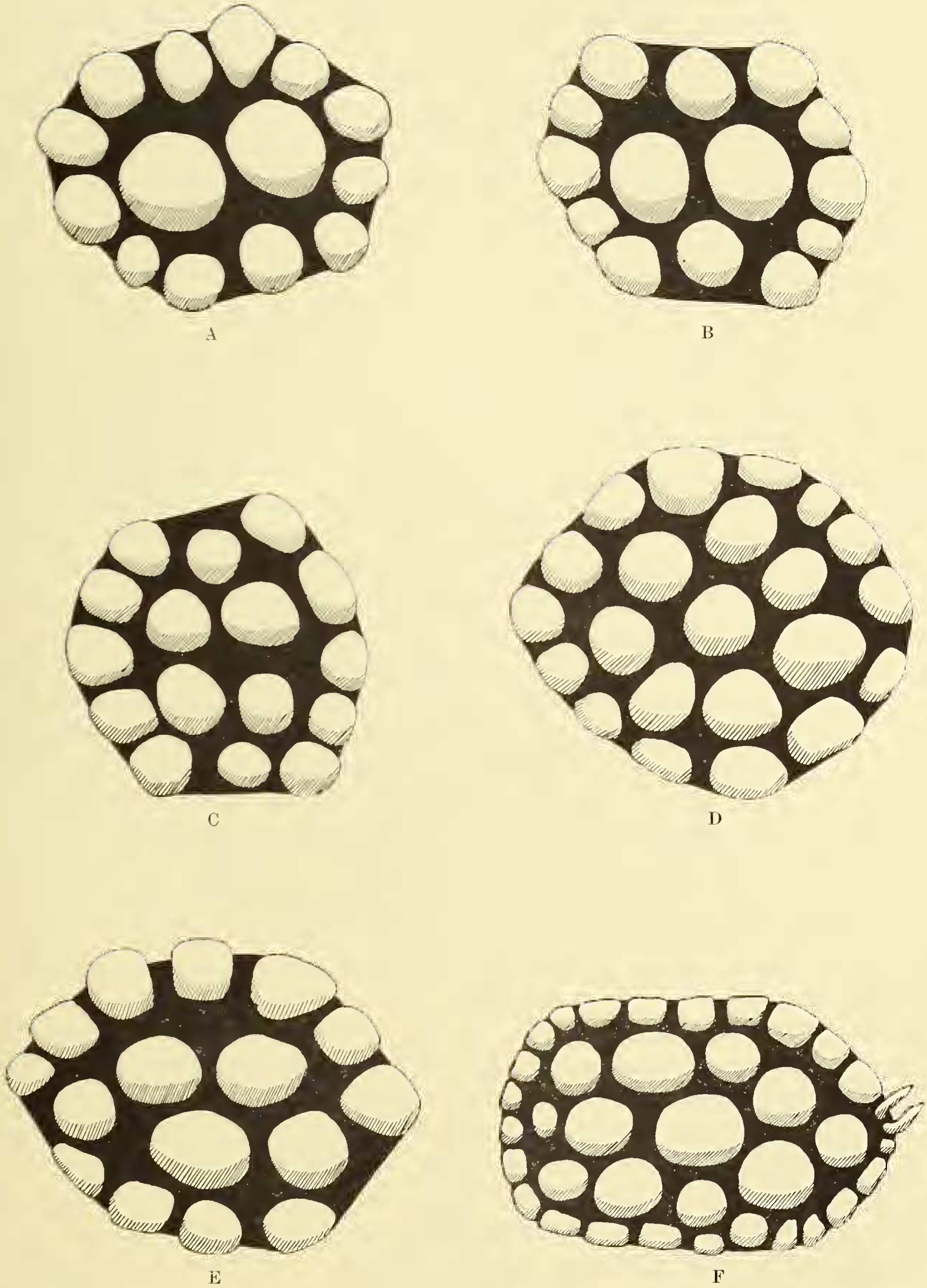
The supero-marginal plates of specimens 100 b, a and e are no more tumid than they may be in the typical form ; the last differs only in its blunt actinal mouth armature and few carinal granules.

These specimens are very like the photographs of *N. alcocki* (Chun, 1900, p. 493), but I have been unable to find a description of this species.

Type B.—Pl. IV, fig. 4, Sts. 105, 108, 110, Zanzibar area, 6 specimens, Cat. no. 17a, c, 40c, 97a, b, c.

No. 17c, the extreme member of the series, differs from the typical form in the following characters : (i) R/r 5·0 ; (ii) the granules surmounting the carinal plates are only fourteen to sixteen in number, of which two to four lie in the centre and the remainder form a peripheral series round them ; (iii) the central granules of the carinal plates are distinctly larger than the peripheral (Text-fig. 8A).

The following intermediate forms occur :



Text-fig. 8.—*Nymphaster mœbii* (Studer). A, 3rd carinal plate × 50 (No. 17*c*; St. 105); B, 5th carinal plate × 50 (No. 97*b*; St. 110); C, 3rd carinal plate × 50 (No. 97*c*; St. 110); D, 3rd carinal plate × 50 (No. 97*a*; St. 110); E, 4th carinal plate × 50 (No. 97*a*; St. 110); F, 5th carinal plate × 25 (No. 40*c*; St. 108).

Cat. No.	r, mm.	R/r.	Number of carinal granules. Peripheral.	Central.	Total.	Relative sizes of carinal granules.
97b	10	4·9	10–14	2–4	12–18	Central larger than peripheral (Text-fig. 8B).
97a	10	5·0	11–17	5–8	16–25	Central slightly larger than peripheral (Text-figs. 8D, and E).
17a	13	4·6	13–15	4–7	17–22	Central larger than peripheral.
40c	25	Arms broken	20–24	10–12	30–36	,, ,, ,, (Text-fig. 8F).
97c	9	Ditto	10–17	6–12	16–29	Central scarcely larger than peripheral (Text-fig. 8C).

It is hoped that the text-figures sufficiently demonstrate that the number and difference in size between the central and peripheral granules of the carinal plates is not a character on which a clear-cut distinction can be based. The R/r ratio varies from 4·6 to 5·0 in this form and from 3·8 to 4·4 in the typical form. The Indian Museum kindly sent me the type of *Nymphaster nora* Alcock and it is found that the present specimens closely resemble this species. Alcock, however, gives the R/r ratio as 6·3 (no arms are whole now), and because of this the species must be regarded as distinct.

Type C.—Pl. IV, fig. 6, St. 122, Zanzibar area, 1 specimen, Cat. no. 98, 16.

No. 98, 16 (r 20 mm.), differs from the typical form in the following characters: (i) Of approximately three hundred actinal intermediate plates one hundred bear pedicellariæ; (ii) the supero-marginal plates are rounded, giving the arms a D-shaped transverse section.

There is, however, an uninterrupted series of forms connecting the round arms of this specimen with the angular arms of the typical form, while the pedicellariæ are unlikely to be of much significance, for another typically round-armed form, No. 98f, has only fifteen, and sixty-five are found on No. 98e, a specimen with typically angular arms.

Type D.—Pl. IV, figs. 3 and 7, St. 145, Maldives, 2 specimens, Cat. No. 95 and 96.

In these two specimens (r 22 and 25 mm.) all the carinals are twice as broad as long and the abactinal surface has in consequence a characteristic facies. Some examples of the typical form, however, approach this condition, and alone it cannot be regarded as a valid specific character.

Koehler's type of *N. belli*, which I have seen, is much smaller than these two specimens, but they are almost certainly one and the same. Koehler separates *N. belli* from *N. ternalis* on the following grounds: (i) *N. ternalis* has a more robust body and stouter arms; (ii) *N. belli* has the carinal plates twice as broad as long, whereas in *N. ternalis* they are roughly hexagonal; (iii) *N. belli* has no pedicellariæ.

Genus *Eugoniaster* Verrill.

The following records exist for this genus:

Species.	Reference.	Number caught.	Locality.	Depth.	Bottom.
E. investigatoris (Alcock)	Alcock, 1893	1	Bay of Bengal	1380 m.	Brown mud.
E. döderleini (Koehler)	Koehler, 1909	1	Minikoi	2160 m.	..

Eugoniaster ephemeralis sp. n. (Pl. II, figs. 2, 4 and 8 ; Text-fig. 9.)

Occurrence :

St. 115, Zanzibar area, 640–658 m. ; 1 specimen.

Diagnosis.—R/r 2. Disk flat, arcuately pentagonal ; arms short, slightly tapering, bluntly rounded at the tip. Abactinal radial plates round or oval, irregularly arranged ; papulæ emerging from spaces between radial plates and extending to a point level with fifth supero-marginal ; interradial plates smaller than radial, angular, with no spaces between them ; all abactinal plates nude except for an occasional small pedicellaria on radials, ornamented with alveolar sculpturing and bordered with truncate granules. Supero-marginal plates eleven, last pair in contact ; plates with rounded outer angles and flat surfaces, except for last four, which are tumid ; abactinal surface with a few granules and some pedicellariæ, lateral surface with many granules ; plates bordered in same fashion as abactinal plates ; size decreasing uniformly except for last three or four plates. Infero-marginal plates corresponding with, and similar to supero-marginals, except that both surfaces are covered with granules. Actinal intermediate areas reaching seventh infero-marginal ; plates in about six chevrons ; plates covered with numerous small round granules, those of innermost chevron usually with small bi-valved pedicellaria as well. Adambulacral plates with about nine short flat spines on the furrow margin and two or three rows of about five granules, with often a bi-valved pedicellaria near the proximal edge, on the actinal surface.

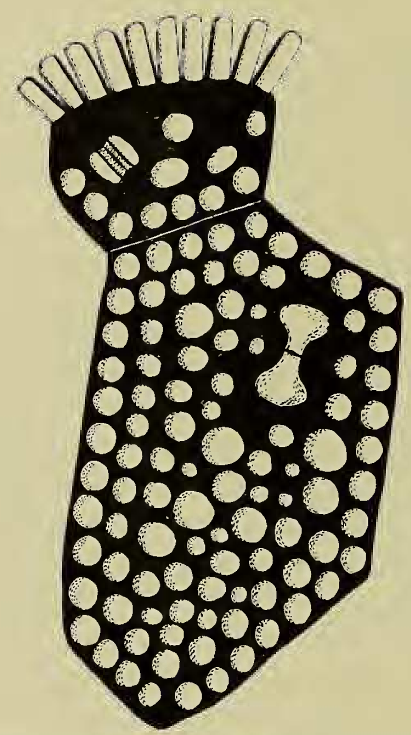
Description.—R 50 mm., r 25 mm. Breadth of arm at level of centre of third supero-marginal plate 11 mm., at level of distal end of eighth supero-marginal 6 mm. The *abactinal radial areas* (Pl. II, fig. 8) are paved with plates which are round or oval, and, therefore, touch each other only at one point, leaving conspicuous triangular or quadrangular spaces, in each of which a papula emerges. The plates are very variable in size, and in consequence fall into no definite linear arrangement in any direction. A section across the radial pore-bearing area at any point will pass through some ten to twelve plates and the breadth of the area is 10 to 13 mm. The plates extend to the last pair of supero-marginals : the papulæ are not found beyond the level of the fifth supero-marginal plate. The plates of the *interradial areas* are a little smaller than the average radial plate and, being angular, fit together without leaving any interspaces. All the plates are naked except for a border of truncate granules and, in some of the radial plates, a small two-valved pedicellaria. The surface is ornamented with an alveolar pattern formed of minute bosses. The *madreporite* is large and encircled by ten plates.

The *supero-marginal plates* number eleven. They have distinct abactinal and lateral faces, but these join at a widely rounded angle. The plates of the interradius and base of the arm are quite flat, but the last three or four, where the tip of the ray turns up, are tumid. The plates are bordered with granules similar to those round the abactinal plates, and the lateral face is closely covered with small round deciduous granules. A few of these granules are found also on the abactinal face, but most of this area is bare except for a few small pedicellariæ in pits. The length of the plates is greater than the breadth, and the breadth is greater than the height. All three dimensions decrease together to the eighth or ninth plate where, owing to the appearance of a median tumidity, the height

and breadth show a sudden increase. The following measurements of supero-marginal plates were taken :

	Plate No.			
	1.	3.	6.	8.
Height	2	2	1·75	2 mm.
Length	4	3·75	3	1 ,,
Breadth	3	2·75	2	2·25 mm.

The *infero-marginal plates* are the counterparts of the supero-marginals except that they have granules on both surfaces.



TEXT-FIG. 9.—*Eugoniaster ephemeralis* sp. n. Adambulacral and actinal intermediate plate × 50.

The *actinal intermediate areas* are extensive and reach the seventh infero-marginal. There are about six chevrons, the two or three innermost clearly defined, but the remainder becoming more irregular in alignment. The number of plates in the successive chevrons is about 25, 15, 10, 7, 4 and 2. The plates of the first chevron are large, usually six-sided and twice as broad as long (Text-fig. 9). The remainder are smaller, diamond-shaped or irregularly quadrangular. Each plate is bordered by a row of uniform low round granules, while the centre is somewhat closely covered by granules of a similar shape but more variable size, some being larger, some smaller than those of the peripheral series. A small bivalve pedicellaria is found on most of the plates of the innermost chevron.

The *adambulacral plates* are slightly longer than broad, and present to the furrow a uniformly rounded margin on which stand nine to eleven short flattened truncate spines

with their edges directed towards the furrow. The actinal surface bears two, or sometimes three, rows of low round granules, four or five in each row. A bivalved pedicellaria often stands near the proximal border of the plate (Text-fig. 9).

The *mouth plates* have a furrow series of thirteen spines similar to those of the adambulacral plates, while the actinal surface of each is decked with twenty to thirty round granules.

AFFINITIES.—The genus *Eugoniaster*, founded by Verrill in 1899 for the reception of the single species *Pentagonaster investigatoris* Alcock, is separated from related genera by remarkably insignificant characters. Verrill himself (p. 173) says, " The character of the pedicellariæ differentiates the genus from *Tosia* and its closer allies ", while Koehler (1909, p. 73), describing *Pentagonaster döderleini*, remarks : " Le *P. döderleini* a des relations avec les espèces du sous-genre *Plinthaster* de Verrill mais elle se distingue des espèces connues telles que les *P. perrieri*, *nitida*, *compta*, etc., par les plaques marginales dorsales qui ne sont pas contiguës a leur congénères vers l'extrémité des bras. Le *P. döderleini* me paraît trouver plutôt sa place dans le sous-genre Eugoniaster." The genus *Pontioceramus* Fisher (1911) differs in having the last five supero-marginal plates in contact, very smooth hexagonal abactinal plates, and an angular furrow margin to the adambulacral plates.

The present example is close to *E. döderleini*, but differs in having the arms broader and less pointed, the papular areas more extensive, and granules on the marginal plates. *E. investigatoris* has shorter arms but more supero-marginal plates. The following is a key to the three species :

A. R/r 1·6 ; supero-marginals 17 ; furrow spines 6 to 7 . . . . *investigatoris*.
B. R/r 2·0 ; supero-marginals 11 ; furrow spines 8 to 11.
  a. Papulæ ceasing at level of distal edge of 2nd SMP. ; surface of marginal plates naked *döderleini*.
  b. Papulæ ceasing at level of distal edge of 4th or 5th SMP. ; lateral face of SMPs. and both faces of IMPs. with granules . . . . *ephemeralis*.

Genus *Lithosoma* Fisher.

The table below shows the recorded occurrences of the species of this genus. All are from the Indo-Pacific region :

Species.	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
L. actinometra Fisher	Fisher, 1911, 1919	2	2	Philippines	208 m.	Mud, shell and coral sand.
	Döderlein, 1924	1	1	Borneo	538 m.	Dark brown sandy mud.
L. actinometra var. *brevipes* Döderlein	,, ,,	1	1	Timor Sea	520 m.	Grey mud.
L. penichra Fisher	Fisher, 1917, 1919	4	4	Philippines	400–800 m.	Green mud ; globigerina ooze.
L. pentaphylla (Alcock)	Alcock, 1893	1	1	Andamans	480 m.	..

Lithosoma ochlerotatus sp. n. (Pl. II, figs. 7 and 9.)

Occurrence :

St. 105, Zanzibar area, 280 m., brown mud ; 1 specimen.

Diagnosis.—R/r 2·5. Body flat ; arms short, wide, blunt at tip ; supero-marginal plates in contact on ray. Abactinal plates regularly hexagonal ; nude except for an occasional pedicellaria on carinals and first laterals and border of small rectangular granules flush with general surface. Six papulæ about each plate in the proximal half of carinal and first lateral rows. Supero-marginal plates bordered in same way as abactinal plates, otherwise naked except for two or three pedicellariæ ; tumid, forming a broad rounded border to arms and disk. Infero-marginals similar to supero-marginals. Actinal intermediate areas small, extending to third infero-marginal ; plates with bordering coarser than that of abactinal and marginal plates, surface naked except for an occasional pedicellaria. Adambulacral plates with five to eight flat furrow spines, of which all but the most distal are set with their edges directed towards the furrow ; actinal surface with a two-, three-, or four-jawed pedicellaria and about four granules on the margin.

Description.—R. 33 mm., r 13 mm. ; breadth of arm at level of fourth supero-marginal plate 8 mm. The first six to eight plates in the carinal and first lateral rows are not in contact with their neighbours and about each one six papulæ emerge ; the remaining plates are all contiguous. Since every plate except those in the carinal row, which are a little broader than long, is an equal-sided hexagon, they lie in an unusually regular arrangement. The carinal row has thirteen plates and the five rows parallel with it 10, 7, 4, 2 and 1 respectively. Round the edge of each plate there is a series of small subquadrangular slightly elongate granules, flush with the general surface, but, except for some of the plates of the carinal and first lateral rows on which two-jawed pedicellariæ occur, there is nothing in the centre, and the bare surface is ornamented with an alveolar sculpturing.

There are ten *supero-marginal plates*, of which the distal seven are contiguous down the ray. The plates are bare except for a marginal series of granules and two or three high spatulate pedicellariæ, which lie close to, and parallel with, the adjacent edges of each plate. All the plates are broader than long, slightly tumid, and their abactinal surface passes into a gentle curve which is continued on the infero-marginals, and gives the animal a rounded border both to the arms and to the disk. The *infero-marginals* are similar to the supero-marginals, but the pedicellariæ lie for the most part parallel with the inner instead of the lateral edges. The breadth of the first two plates is nearly twice the length, but subsequent plates are narrower and those at the tip of the ray are longer than broad.

The *actinal intermediate areas* are small and reach only the third infero-marginal. There are four chevrons, containing successively 7, 4, 2 and 1 plates. These plates are four-sided and their surface sculpturing is similar to that of the abactinal plates, though the granules round the edge are larger. One or two pedicellariæ occur on most of the plates of the innermost chevron and occasionally on other plates as well.

The *adambulacral plates* have a uniformly convex furrow margin. On the first plate there are five furrow spines, and the number increases on successive plates till it reaches

eight. The spines are short and compressed. The proximal spines present their edges, the distal spine of each plate its flat surface, towards the furrow. On the actinal surface there is a pedicellaria with two, three or four jaws, and near the outer margin stand two, three or four granules.

The *mouth-plates* bear six furrow spines and on the actinal surface two rows of granules, of which the two innermost are elongated.

Affinities.—On account of the characters of the abactinal plates with their complete ring of granules, the flat adambulacral furrow spines with the long axis of the most distal at right-angles to that of the rest, and the general abundance of pedicellariæ, I have no hesitation in assigning the present specimen to the genus *Lithosoma*, though the difference between it and *Iconaster* is slight. It is, however, with hesitation that a new species is created, for the difference in size between the present and the two previously described species is considerable. On account of this, characters such as the number of superomarginal plates, the R/r ratio, and the number of furrow spines, *i. e.* the characters wherein the main differences lie, must be treated with the utmost suspicion. It would seem, however, that the discrepancies are so great that they cannot be due entirely to growth changes, and that the present specimen must receive specific recognition.

The following table shows the differences between the three species :

		L. actinometra.	*L. penichra.*	*L. ochlerotatus.*
R		155 mm.	86 mm.	33 mm.
R/r		3·7	4·0	2·5
Adambulacral plates.	Furrow margin	6–11 spines, margin convex	5–10 spines, margin angular	5–8 spines, margin convex.
	Actinal surface	One to three 2-jawed pedicellariæ	One 2- or 3-jawed pedicellaria	One 2-, 3- or 4-jawed pedicellaria.
Number of SMPs.		40	32	10
Papulæ		All over disk	Confined to radial areas	Confined to radial areas.
Abactinal pedicellariæ.		Very small	Small	Small.
Act. int. areas		Irregular	Irregular	Regular.

Remarks.—Fisher (1919, p. 301) regards the species described by Alcock under the name of *Dorigona pentaphylla* as very close to, or possibly identical with, *Lithosoma actinometra*.

Describing *Iconaster gardineri*, Bell (1909, p. 22) remarks : " There are three specimens of different size in this genus and I may remark that one of them is so minute that it does not exhibit the leading characters of the genus." Fisher (1919, p. 309) refers to this species as " typical *Nymphaster* related perhaps to *N. dyscritus* Fisher ". I have examined Bell's three specimens at the British Museum. The two larger undoubtedly are *Nymphaster*, but the small one has naked plates throughout and is not. It is close to the present genus.

Genus *Astroceramus* Fisher.

The following records, all from the Indo-Pacific region, exist for this genus :

Species.	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
A. callimorphus Fisher	Fisher, 1906	1	1	Hawaiian Is.	230 m.	Fine sand, yellow mud.
A. lionotus Fisher .	,, 1913	1	1	Philippine Is.	..	..
A. sphæriosticus Fisher	,, ,,	1	1	,, ,,	292 m.	Coral sand.
A. fisheri Koehler .	Koehler, 1909	3	1	Between Maldive Is. and Colombo	400–500 m.	..
	Döderlein, 1924	1	1	Moluccas	827 m.	Hard ground.

Astroceramus cadessus sp. n. (Pl. II, figs. 3 and 5 ; Text-fig. 10.)

Occurrence :

St. 157, Maldives, 229 m., coral rock ; 2 specimens.

Diagnosis.—R/r 2·8. Disk flat ; arms tapering, rectangular in cross-section ; interbrachial arcs widely rounded. Abactinal plates hexagonal, regularly arranged ; bare centrally, bordered with truncate granules. Supero-marginals in contact along arms ; slightly tumid on disk, flat on arms ; bordered similarly to abactinal plates ; lateral surface with hemispherical deciduous granules. Infero-marginals corresponding to supero-marginals only in interradius and at tip of ray ; bordered in similar fashion but with granules on both lateral and actinal faces. Actinal intermediate plates in three chevrons, the outermost enclosing an irregularly arranged group ; bordered with granules coarser than those of abactinal and marginal plates ; centre with one to six granules a little larger still ; pedicellariæ on plates of innermost chevron. Adambulacral plates with furrow series of six or seven flattened spines and with two series on actinal surface, the inner of a granule and two spines, one large flattened rounded at the tip, the other similar but barely half the size, the outer series of four or five truncate or pointed granules.

Description.—R 50 mm., r 18 mm., R/r 2·8 ; R 35 mm., r 12 mm., R/r 2·9. The *abactinal plates* are regularly arranged, hexagonal in shape and a little broader than long. There are about fourteen carinal plates and on either side three well-defined rows of similar but somewhat smaller plates. Beyond them there is a triangular area in which the plates, about thirty in all, are more irregular both in outline and arrangement. All the abactinal plates are quite bare centrally, ornamented with an alveolar sculpturing and bordered by small subtruncate granules flush with the surface. A papula emerges at the corner of each plate except of those in the centre and in a small triangular region within the interradial area.

There are fourteen *supero-marginal plates*, of which the distal eleven are in contact with their opposites down the length of the ray. The abactinal and lateral faces meet at a right-angle ; the former is flat on the arms and slightly convex on the disk. There is a granular border similar to that of the abactinal plates, and the lateral face is closely

covered with about twenty-five deciduous hemispherical granules. Some of these encroach on to the abactinal surface of the first few plates, but are absent from this region of the remainder. The length of the plate is greater than the height throughout. The breadth is equal to the length in the first plate, becomes greater at the base of the arms and then equal again, from which point all three dimensions decrease uniformly to the tip of the ray. Measurements taken from the larger specimen are :

	Plate No.			
	1.	4.	8.	12.
Height . . .	2·5	2·5	1·75	1·5 mm.
Length . . .	3·25	3·25	2·5	1·75 ,,
Breadth . . .	3·25	4	2·5	1·75 ,,

The *infero-marginal plates* are longer than the supero-marginals and only correspond to them in the interradius and at the tip of the ray. Their bordering and granulation is similar except that granules occur on both faces. The dimensions of plates from the larger specimen are :

	Plate No.			
	1.	4.	8.	12.
Height . . .	2	2	1·5	1 mm.
Length . . .	3·25	3·75	2·75	2 ,,
Breadth . . .	3·5	2·5	1·25	1 ,,

The terminal plate is armed with three short spines.

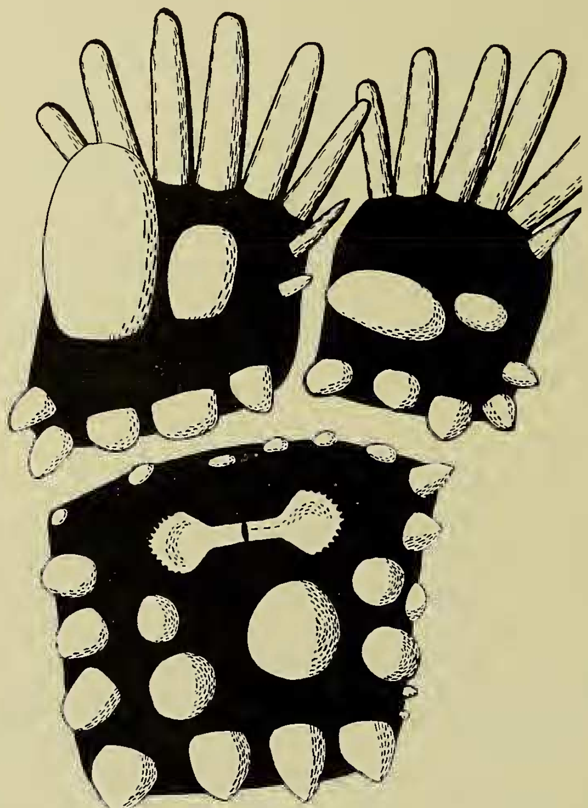
Actinal intermediate areas.—It is possible to make out three chevrons containing successively 11, 7 and 4 plates. The outermost of these chevrons encloses about ten plates falling into no regular order. The edge of each plate bears a series of bordering granules, which are more variable in size, though on the average larger and more spaced, than those of the abactinal and marginal plates. The centre of the plate is occupied by one to six hemispherical granules, a little larger than those of the peripheral series, and on the plates of the innermost chevron a bivalved pedicellaria usually occurs as well (Text-fig. 10).

Adambulacral plates.—There are six or seven furrow spines. The adoral is smaller, more pointed than, and set back a little from the rest, which are long delicate flattened and rounded at the tip. On the actinal surface there is an inner series consisting of a small pointed granule and two spines, the larger very broad, as long as the furrow spines, flattened and rounded at the tip, the second similar but barely half the size, and an outer series consisting of four or five pointed or subtruncate granules (Text-fig. 10).

The *mouth plates* have a furrow series of nine spines, similar to those of the adambulacral plates, and their actinal surface is traversed by two rows, of which the first, parallel with the suture between adjacent plates, consists of four granules distally and two wedge-shaped spines proximally, and the second, parallel with the suture between the mouth plate and first adambulacral, consists of two granules. Inside the triangular area enclosed by these two series and the furrow spines there is a single enlarged spine similar to those on the adambulacral plates.

Colour.—In spirit: white with a line of red-brown pigment running between all the plates of the abactinal surface. In the smaller specimen there is a patch of similar but rather lighter colour on the abactinal surface of each of the first two supero-marginal plates.

Affinities.—The species is, perhaps, related to the Hawaiian form, *A. callimorphus*, but the arms are shorter, in which character it is intermediate between *A. callimorphus*



Text-fig. 10.—*Astroceramus cadessus* sp. n. Adambulacral and actinal intermediate plates × 50.

and *A. fisheri*. Other characters by which it may be distinguished from the former lie chiefly in the adambulacral armature, for *A. callimorphus* has more actinal granules, fewer furrow spines and the enlarged actinal spines subequal. *A. fisheri* is distinguished at once by the fact that out of a total of thirteen supero-marginals five bound the paxillar area and only eight are in contact. In *A. cadessus* three supero-marginals out of a total of fourteen bound the paxillar area of the disk. The differences separating the five known species are expressed in the accompanying key:

I. Ratio of number of SMPs. bounding paxillar area to total number of SMPs. less than 1 : 3 . *fisheri.*
II. Ratio of number of SMPs. bounding paxillar area to total number of SMPs. at least 1 : 5.
  1. R/r 2·8; furrow spines 6 to 7 . . . . *cadessus.*
  2. R/r greater than 3; furrow spines 4 to 5.
    i. Abactinal surface without granules:
      A. Furrow spines sligthly compressed, truncate . . . . *callimorphus.*
      B. Furrow spines strongly compressed, broadened at tip . . . . . *lionotus.*
    ii. Abactinal surface with granules . . . . *sphœriosticus.*

Genus *Milteliphaster* Alcock.

Milteliphaster wood-masoni Alcock.

Milteliphaster wood-masoni, Alcock, 1893, p. 91, pl. vi, figs. 5, 6, 7.

OCCURRENCE :

St. 157, King Fuad Bank, Maldives, 229 m., coral rock ; 2 specimens.

DISTRIBUTION.—Andaman Sea ; Maldives ; 229–529 m.

REMARKS.—Alcock's description states : " Each supero-marginal carries . . . a large coarse spine . . . at the tip of the ray the plates have two spines . . . a few of the plates also have one of the large pedicellariæ." The smaller specimen agrees with this description except that most of the supero-marginal plates are armed with two spines. In the larger specimen some of the supero-marginals bounding the paxillar area, and all beyond the sixth or seventh plate, are armed with two spines, and many of them, particularly those about the paxillar area, bear two or even three pedicellariæ. Further, in the larger specimen the supero-marginals do not all lie laterally and vertically, as in the type described by Alcock and in the smaller specimen, but along most rays and in some interradii as well they are abactinal and almost horizontal.

Alcock's type has nine or ten furrow spines. The smaller of the two present specimens has nine on every plate, while the larger has ten furrow spines on the proximal plates and the number increases on subsequent plates till it reaches fourteen.

The dimensions of the two specimens are R 83 mm., r 23 mm., R/r 3·6 ; R 80 mm., r 23 mm., R/r 3·5.

Genus *Mabahissaster* gen. n.

DIAGNOSIS.—Arms five ; disk pentagonal ; arms moderately long, composed abactinally of supero-marginal plates only. Abactinal plates large, irregularly polygonal, bare except for a border of granules, an occasional pedicellaria and a large coarse spine on many plates in the proximal region of each radial area. Supero-marginal plates bare except for a border of granules, armed with one or two large spines. Infero-marginals similar except that surface may bear granules. Actinal intermediate areas rather small ; plates with border of granules, centre occupied by granules, a pedicellaria on a raised tabulum or a spine. Adambulacral plates with numerous furrow spines ; actinal surface with granules, pedicellariæ and spines.

REMARKS.—The granulation of the plates and the presence of numerous distal supero-marginal plates in contact suggests affinities with *Astroceramus* and related genera. None of these, however, bear abactinal or marginal spines. This feature of the genus *Mabahissaster* recalls *Milteliphaster* and *Calliaster*, but in both these genera the supero-marginals are separated by rows of abactinal plates.

Mabahissaster zengi sp. n. (Pl. VI, figs. 1 and 2 ; Text-fig. 11.)

OCCURRENCE :

St. 106, Zanzibar area, 183–194 m., green mud ; 1 specimen.

DIAGNOSIS.—R/r 3·3. Disk fairly thick, slightly raised abactinally, slightly concave

actinally. Arms rather narrow, tapering slowly to a blunt tip. Interbrachial arcs widely rounded. Abactinal surface beset with rather large polygonal, rectangular or round plates ; in radial areas plates varying much in size, in five regular radial rows ; in interradial areas plates smaller and irregular in disposition ; robust tapering spines on about half total number of carinal plates, becoming progressively scarcer on first and second lateral rows of plates ; plates nude except for border of subtruncate granules ; pedicellariæ on many radial and some interradial plates. Supero-marginal plates with well-marked abactinal and lateral surfaces ; plates of arm in contact ; outer edge bearing coarse spine similar to those of abactinal plates, a second similar spine near inner edge of first two plates ; border of granules, surface nude. Infero-marginal plates corresponding to supero-marginals except towards tip of ray ; similar but with spines fluted near tip, and scattered granules on actinal surface. Actinal intermediate areas small, plates rather indefinitely arranged ; border bearing subtruncate granules, centre occupied usually by large pedicellaria set on tabulum, sometimes by granules, very occasionally by fluted spine. Adambulacral plates with seven to nine short crowded furrow spines ; border of plates bearing granules, centre usually occupied by about six granules, one fluted spine and one pedicellaria.

Description.—R 82 mm., r 25 mm. *Abactinal surface.*—The centre of the disk is occupied by a spine-bearing plate whose diameter is 3·75 mm. Around this plate there is a ring of nine plates, five radial and four interradial. Each radial plate is about 2·5 mm. in diameter and is armed with a spine, while the interradials are slightly smaller, about 2 × 2·5 mm., oval in shape and unarmed. The five largest plates of the disk, each armed and measuring about 4 × 5 mm., lie on the interradial line just outside the ring of plates. All these interradial plates are longer than broad. Co-serial with the radial plates of the ring the carinals, fifteen to eighteen in number, extend to the proximal edges of the fifth supero-marginal plates. The plates are broader than long, polygonal or rectangular in shape and the edges are rounded. The sequence of plates is not identical along each radius, but the following description covers three radii ; the fourth is similar except that a small unarmed plate separates the first carinal from the radial plate of the ring. The first plate measures about 3 × 3·5 mm. and bears a spine, the second plate is narrow and unarmed and the third to seventh plates all bear spines. The first of these five plates is usually the largest in the carinal row and measures about 4 × 3·75 mm. Each of the others is usually a little narrower than the plate on the proximal side of it. The eighth plate is narrow and unarmed, the ninth is armed, and the rest of the carinals, six to eight in number, are without spines, much compressed and measure about 3 × 1·25 mm. A small diamond-shaped plate may lie isolated between the fifth and sixth supero-marginals.

The plates of the first lateral row are smaller than those of the carinal, and more or less rounded in shape. The first two are small, 1 to 2 mm. in diameter, and usually unarmed. The third is commonly the largest, 3·25 mm. in diameter, and the remainder decrease gradually in size to the proximal end of the fourth supero-marginal where the series ceases. There are fifteen or sixteen plates, and of the first six, three or four bear spines. The second lateral row is less regular. There are ten or eleven plates, a little smaller than those of the first lateral row. One or two bear spines.

In the interradial area lie about twenty-five small polygonal or rounded plates, 1 to 2 mm. in diameter. They are without spines, though some may bear a small central tubercle.

The abactinal plates present a slightly convex smooth surface round which is a border of flat subtruncate granules. The spines are borne on raised bosses. The base of the spine is rounded and tapers rather rapidly. About a third of the way up the rate of taper becomes less and continues evenly to a fine rounded point. The spines are 4 to 6 mm. high. A few of the interradial plates have a single pedicellaria, and on many of the radial plates, both armed and unarmed, there are one or two pedicellariæ, which consist of a short stalk suddenly flaring into a broad kidney-shaped jaw. They lie in shallow depressions, and when wide open measure a little over 1 mm. from the tip of one jaw to the tip of the other.

The *supero-marginal plates* number fourteen or fifteen. The fifth pair are in contact across the base of the ray. They form a broad sloping border to the paxillar area and a broad flat roof to the rays. Dimensions are :

	Plate No.					
	1.	3.	5.	7.	10.	14.
Height	3	3·5	3·5	3	2·5	1·5 mm.
Length	4	5	5	4·5	4	2·5 ,,
Breadth	7	5	6	4·5	4	2·5 ,,

It will be seen that the height is small but increases slightly up to the fifth plate. The breadth of the first plate is greater than the length, but on subsequent plates it decreases and the length at first increases slightly, so that from the third plate outwards the two dimensions of all plates except the fifth, which are the first pair to meet abactinally, are equal. The outer free border of each plate rises gradually into a large swelling, on which stands a spine resembling the spines of the abactinal plates. A second similar spine stands near the inner border of the two plates on either side of the interradial line. The plates are naked, but bordered with granules similar to those round the abactinal plates. There is no trace of pedicellariæ.

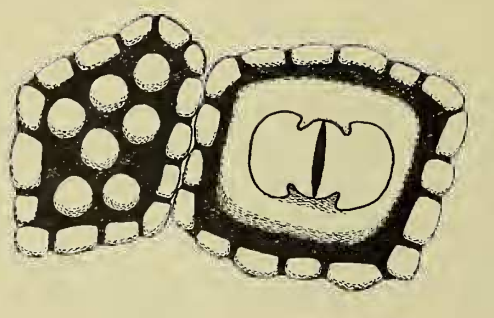
The *infero-marginal plates* correspond to the supero-marginals except towards the tip of the ray, where they become a little longer. Here, also, they are almost confined to the side wall. Dimensions are :

	Plate No.				
	1.	3.	6.	9.	13.
Height	3	3	2	1·5	1·5 mm.
Length	5	5	5	4·5	4 mm.
Breadth	4·5	4·5	2·5	2	1 ,,

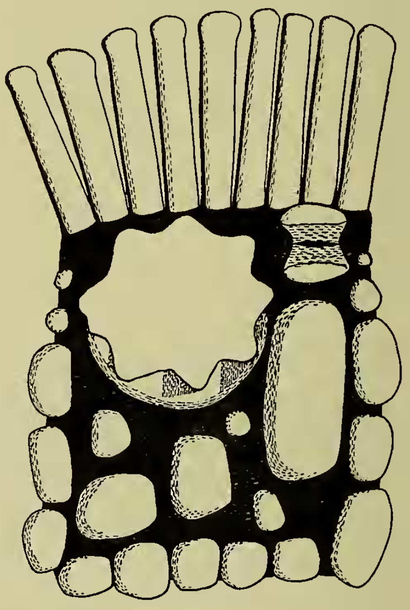
The outer edge of each plate bears a spine similar to those of the supero-marginals except for the fact that the outer third is fluted. The plates are bordered with granules, but on the inner edge of the first two or three plates a second and sometimes a third row of granules lies inside the bordering series. Scattered granules or isolated groups occur elsewhere on the actinal surface of the plate. The first two plates bear pedicellariæ.

The *actinal intermediate areas* are small and extend only to the centre of the third

infero-marginal. The plates are irregularly quadrangular, about 2 mm. across. An inner chevron of about nine plates is definite, the next one has five or six plates in less regular order, and outside it there are four or five plates which are not clearly arranged in chevrons. Around the edge of each plate there are ten to twenty flat subtruncate granules, and the centre is usually occupied by a blister-like tabulum on which is lodged a pedicellaria, similar to those of the abactinal plates but twice as large. When there is no pedicellaria the surface of the plate is partially or wholly covered with rather low coarse hemispherical or angular granules (Text-fig. 11A). Two plates in one interradius and one in another bear a spine, 3·5 mm. long and fluted at the tip.



A



B

Text-fig. 11.—*Mabahissaster zengi* sp. n. A, Actinal intermediate plates × 12·5 ; B, Adambulacral plate × 25.

The *adambulacral plates* (Text-fig. 11B) bear seven to nine short flattened closely crowded furrow spines, slightly swollen at the tip. Round the edge of each plate there are about fifteen flat subtruncate granules. The outer half of the actinal surface is occupied by about six low angular granules, and near the proximal border there is a tabulum, similar to, though smaller than, the structure on the actinal intermediate plates. It is possible that these tabula represent a group of granules fused together. Between the tabulum and the furrow spines there is a pedicellaria, and on its distal side a coarse cylindrical spine which is 4 mm. long and has a fluted tip. Occasionally either the spine or the pedicellaria is absent, and some plates have two spines, one outside the other, and a pedicellaria may or may not be present as well.

The *mouth plates* bear twelve to fifteen furrow spines, and on the actinal surface there are some scattered granules and a single spine.

Colour.—Abactinal face, army brown with the spines a little darker ; actinal face pale flesh-coloured ; the two colours merging along the side of the disk and arms.

Sub-family ANTHENOIDINÆ.

Genus *Stellaster* Gray.

Döderlein (1935, p. 86) gives a revision of this genus.

Stellaster equestris (Retzius).

Asterias equestris, Retzius, 1805, p. 12.
Stellaster childreni, Gray, 1840, p. 278.
Stellaster equestris, Müller and Troschel, 1842, p. 128, pl. iv, fig. 3, pl. vi, fig. 5; Goto, 1914, p. 411, pl. xiii, figs. 213–218, pl. xiv, figs. 219, 220; Döderlein, 1935, p. 91.

OCCURRENCE:

St. 72, Gulf of Oman, 73 m., coarse sand and shells; 16 specimens.

DISTRIBUTION.—Japan (Lütken, Müller and Troschel, Gray). China (Gray, von Martens), Formosa Strait and South China Sea (Lütken). Sonda Islands and Andaman Islands (Koehler). Red Sea (Dollfus); Gulf of Oman.

DESCRIPTION.—R 56–68 mm., r 21–25 mm., R/r 2·5–2·8. The *pores* occur in groups of two or three between the radial plates, and in groups of about ten between the radial and supero-marginal plates. They extend nearly to the tip of each ray, and a few are also found between the plates in the centre of the disk and in the interradial areas. All the specimens have a *tubercle*, or at least the scar from which a tubercle has been rubbed, on the first carinal plate, and a few have a second placed on the third carinal of each radius. A single specimen has three tubercles on one radius, but it has been rubbed so badly that it is not possible to make out if the same condition obtained on any of the other arms.

The *supero-marginal plates* number fifteen to seventeen. Each one is slightly tumid and finely granular, and on most one or two sunk elongate pedicellariæ are found. The *infero-marginal plates* correspond to the supero-marginals, and each is armed with a flattened mobile spine.

The *actinal intermediate plates* are about forty in number. They are arranged in two chevrons, the inner containing ten, the outer seven plates, which enclose one or two odd plates.

The *adambulacral plates* bear a furrow series of five or six short spines, arranged in a palmate group united by membrane at the base. On the actinal surface stand two large flattened spines which are sometimes subequal, though usually one is three times as long as the other. A two-jawed pedicellaria occurs near the proximal edge of most plates.

Genus *Stellasteropsis* Dollfus.

Stellasteropsis colubrinus sp. n. (Pl. V, figs. 2 and 5.)

OCCURRENCE:

St. 24, Gulf of Aden, 73–200 m., coarse sand and shingle; 1 specimen.
St. 27 ,, ,, 37–91 m., sand and shingle; 2 specimens.
St. 45, Arabian coast, 38 m., Lithothamnion; 26 specimens.
St. 53, ,, ,, 13·5 m., rock, shell, shingle and Lithothamnion; 1 specimen.

Distribution.—There are in the British Museum two specimens which belong to this species. They bore the following labels :

"*Stellaster*, 87. 6. 5. 4. Muscat, Col. Miles."

"*Stellaster* yg. 1903, 4. 2. 53. Wasin, coll. Crossland."

Diagnosis.—R/r 3. Body star-shaped ; arms tapering, their sides straight, meeting at an angle at apex of interbrachial arcs. Abactinal surface slightly raised along radii, actinal surface flat. Abactinal plates in regular central, interradial and radial series ; papulæ emerging from between latter. Supero-marginal plates tumid ; last pair in contact. Infero-marginal plates nearly flat ; last four or five plates with tubercle on outer distal corner. Actinal intermediate plates gently convex, unarmed ; arranged in about three chevrons and one or two rows of small plates parallel with infero-marginals. Adambulacral plates and mouth plates bearing only a furrow series of short flat spines which form a continuous palisade roofing adambulacral grooves throughout their length. Entire body covered by membrane and bearing close-set granules ; granules progressively larger on the abactinal, marginal, actinal intermediate and adambulacral plates ; pedicellariæ absent.

Description.—The following description is taken from the largest member of the collection, the single specimen from St. 53. Its dimensions are : R 55 mm., r 18 mm., R/r 3·0. Measurements of arms :

	SM Plate No. 1.	3.	6.	9.	15.	
Breadth of ray	20	16	10·5	7·25	4·5	mm.
Breadth of paxillar area	10	8	4	2	0·75	,,

Abactinal surface.—There is a single plate, with the anus to one side of it, lying in the centre of the disk. Around this plate lies a ring of six plates and outside again a ring of ten plates, five radial and five interradial. There is only one other interradial plate which, compressed and lozenge-shaped, lies completely surrounded by three pairs of plates. These plates which are larger than their neighbours and have papulæ only on the side away from the interradial line are the first plates of the three lateral radial series. The carinal plates, which are hexagonal or oval and broader than long, number thirty-two and extend to the last pair of supero-marginal plates. Parallel with them are three rows of similar but slightly smaller plates. In the first row there are fifteen plates reaching the seventh supero-marginal, in the second seven plates reaching the fourth supero-marginal and in the third only three small plates. About the plates near the centre of the disk as many as ten papulæ may emerge, but the number per plate decreases along the ray and the papulæ cease in the neighbourhood of the twentieth carinal plate. The abactinal surface is covered with membrane in which is lodged a number of close-set polygonal granules, of which a single series round the edge of each plate is somewhat enlarged. The rims of the pores are also surrounded by enlarged granules.

The *supero-marginal plates* number seventeen, and all, except the last pair, are separated by abactinal plates. Each one is strongly tumid. A widely rounded angle joins the abactinal and lateral faces which lie respectively horizontally and vertically. At the apex of three of the interradii lie a pair of plates, while at the apex of the other two there is a single unpaired plate. Each one of these eight plates is truncately triangular. The remaining supero-marginals are rectangular when viewed from the abactinal surface. The dimensions of the plates are :

	Plate No. 1.	3.	6.	9.	12.	
Height	4	4	3	2	1·5	mm.
Length	2–4	3·25	2·5	2·25	2·25	,,
Breadth	5	4·5	3·5	3	2·25	,,

The plates are covered by a membrane in which is embedded a close granulation, a little coarser than that of the abactinal plates. The granules are all of one size except for those in the two rows which run round the edge of the plate. These are larger, and form a margin which is particularly conspicuous between the plates.

The *infero-marginal plates* correspond to the supero-marginals but their height is less and they are almost flat. The granulation is similar. The outer distal corner of the last four or five plates is produced into a short papilliform tubercle.

The plates of the *actinal intermediate areas* are rather irregularly disposed. The innermost chevron of fifteen to seventeen plates, reaching the sixth or seventh infero-marginal plate, is quite definite, but the next two with about nine and four plates respectively are less well marked. The rest of the plates are small, number about five, and lie in one or two rows parallel with the infero-marginals. Each plate has a gently convex surface covered with membrane in which the granules are uniform and a little coarser than those of the marginal plates.

The actinal surface of the *adambulacral plates* and the *mouth plates* is covered with granules distinctly coarser than those of the actinal intermediate plates, while the furrow margin bears four or five short flattened truncate spines. The axis of flattening is parallel with the furrow, and the spines stand in an uninterrupted palisade which roofs in the ambulacral groove throughout its length.

Young Forms.—Twenty-six specimens were taken at St. 45, but the largest, with R 37 mm., is a good deal smaller than the single example from St. 53, described above. There are certain noticeable differences between the specimens from the two stations: (i) in all the smaller specimens the interbrachial arcs are rounded; the marked angle of the larger specimen is never seen: (ii) the arrangement of papulæ is very regular in all the smaller specimens, there being one at each corner of the hexagonal radial plates. As many as ten about a plate are found in the larger specimen; (iii) the majority of the smaller specimens have a pair of plates at the apex of each interradius. Single plates such as occur in the larger specimen are found in only three of the twenty-six.

These three points are probably variations and independent of growth. The changes believed to be due to growth are tabulated below: (i) The R/r ratio shows a steady increase, thus; R 8 mm., R/r 2·3; R 37 mm., R/r 2·8; R 55 mm., R/r 3·0. (ii) The number of plates shows the following increase:

R	8	12–22	23–37	55 mm.
Number of carinals	11	14–17	24	32
Number of 1st laterals	4	..	..	15
Number of SMPs.	5	..	..	17

In the smallest specimen (R 8 mm.) the actinal intermediate areas are paved with two chevrons, containing respectively four and two plates.

Affinities.—I have compared the largest member of the present collection with the syntype of *Stellasteropsis fouadi* Dollfus (1936) in the British Museum. The two specimens are almost exactly equal in size, and in the number and arrangement of plates they are almost identical. It is found, however, that the present examples have much more tumid supero-marginals than *S. fouadi*, and differ further in that the distal infero-marginal plates bear tubercles, and pedicellariæ are absent. These features are small and might well fall within the range of variation of a single species, but in the absence of intermediate forms it is felt that this view is not justified, and a new species, *S. colubrinus*, has been created.

Stellasteropsis tuberculiferus sp. n. (Pl. V, figs. 4 and 7.)

Occurrence :

St. 45, Arabian Coast, 38 m., Lithothamnion ; 1 specimen.

Diagnosis.—General form similar to *S. colubrinus*, but arms less tapering and broader at tip ; interbrachial arcs rounded. Abactinal plates in regular central, radial and interradial groups ; covered with membrane with a close uniform granulation ; tubercles on many radial plates. Pores extending nearly to tip of ray, absent only about plates on interradius. Supero-marginals similar in shape to those of *S. colubrinus* ; differing in that granulation becomes coarser towards centre of plate, and plates of distal half of ray bear one or two tubercles. Lateral face of infero-marginals with a group of enlarged granules of which, on the distal half of the ray, two to four become further enlarged and project as tubercles. Actinal intermediate areas rather small ; plates convex, with granules which become larger as the centre of the plate is approached. Adambulacral plates, as in *S. colubrinus*, with only coarse granules actinally, and a furrow series of five spines roofing in the furrow.

Description.—The specimen has the following dimensions : R 44 mm., r 16 mm., R/r 2·7.

	SM Plate No.				
	1.	3.	6.	11.	13.
Breadth of arm . . .	16	13·5	9	5·5	4 mm.
Breadth of paxillar area .	11	6	3·5	1·25	..

The anus, the position of which is marked by a ring of tooth-like granules, is surrounded by four small plates. Around these lie eight plates, of which five are radial in position. Co-serial with these latter, twenty-two carinal plates extend to the last pair of supero-marginals, which are in contact. In shape the carinals are hexagonal, the breadth slightly exceeding the length. Thirteen plates, reaching the eighth supero-marginal, and six plates, reaching the fourth supero-marginal, make up the first and second lateral rows respectively. Three small plates, reaching the second supero-marginal, may be said to make up a third lateral row. In the interradius the arrangement of plates is variable. Usually there are four large median plates, but some of these may be replaced by a pair. The plates are covered with membrane in which is embedded a close uniform granulation. In the centre of the proximal seven to nine plates of the first lateral row, the proximal three or four plates of the second lateral row, and a few carinals, there is a short tubercle whose diameter is three or four times that of the granules which lie around it.

Papulæ emerge everywhere except around the interradial plates and the last three or four carinals. Eight to ten papulæ occur around the proximal six to eight plates, six around the next six plates, and four around the next four plates of the carinal row. A similar distribution of papulæ is found around the plates of the first and second lateral rows, though, of course, here the numbers fall off more rapidly.

The *supero-marginal plates* number fourteen. Each one is broader than long, and tumid with a widely rounded angle between the abactinal and lateral faces. Around the edge of the plate the granules are equal in size to those of the abactinal plates, but as the central line of the plate is approached the granules increase to two or three times the size of those at the edge and also become more widely spaced from one another. The last five or six plates bear one or two tubercles on the outer distal corner.

The *infero-marginal plates* correspond to the supero-marginals, but their height is a little less and they are not tumid. The granulation of the actinal face is uniform and similar to that which is found at the edges of the supero-marginals. The lateral face bears a group of about a dozen enlarged granules, of which two to four on the last five or six plates develop further and project as tubercles some 0·5 mm. long.

The *actinal intermediate plates* are arranged in the same rather irregular manner as those of *S. colubrinus*. There are three chevrons, the first well defined, the remaining two less so, and a few plates lying in a row parallel with the infero-marginals. Eleven plates, reaching the fifth infero-marginal, make up the innermost chevron, and about six and three plates respectively the other two. The plates are convex and closely covered with granules, which become larger as the centre of the plate is approached. The granulation of the actinal surface of the *adambulacral plates* is uniform, the granules being equal in size to those in the centre of the actinal intermediate plates. The furrow spines, about five to a plate, form a sloping roof over the furrow and are very like those of *S. colubrinus*.

Affinities.—In general characters there is a close resemblance between *S. colubrinus* and *S. tuberculiferus*, but they may readily be separated by the following features: (i) the arms taper less in *S. tuberculiferus*; (ii) the arrangement of the plates in the centre of the disk is different in the two species; (iii) in *S. tuberculiferus* the abactinal granulation is uniform, and the largest supero-marginal plate granules are found in the centre of the plate, not at the edge as in *S. colubrinus*; (iv) *S. colubrinus* has infero-marginal tubercles only; *S. tuberculiferus* has tubercles on the abactinal plates and on both series of marginal plates.

Genus *Monachaster* Ludwig.

Monachaster umbonatus sp. n. (Pl. V, figs. 3 and 6.)

Occurrence:

St. A, Gulf of Suez, 65–68 m., soft yellow mud; 1 specimen.

Diagnosis.—Abactinal surface slightly raised, actinal surface flat. Arms scarcely tapering, rounded at the tip. Interbrachial arcs widely rounded. Abactinal plates covered with membrane bearing uniform granulation; some plates with flat round boss whose diameter is a little more than half that of plate on which it stands; other plates with low valvate pedicellariæ. Pores around all abactinal plates, absent only from inner side of plates on either side of interradial line. Supero-marginal plates tumid;

edges with small elongate granules, centre with mosaic of enormous polygonal granules. Infero-marginal plates with a similar granulation on lateral face ; on actinal face granules smaller and tending to imbricate. Actinal intermediate plates with granulation coarser than that of abactinal plates, granules tending to imbricate ; some plates with low valvate pedicellariæ. Adambulacral and mouth plates with actinal surface covered with granules finer than those of actinal plates ; furrow spines as in *Stellasteropsis*.

Description.—R 27 mm., r 12·5 mm., R/r 2·2. Four plates surround the anus and around these lie a ring of eight, of which five are radial and three interradial. In the other two interradii there is a single median plate lying just outside the ring. There are no other median interradial plates at all, and on either side of the interradial line lie four plates, all except the outermost the first of a row parallel with the carinals. There are nineteen carinal plates reaching the penultimate pair of supero-marginals. The plates are oval or hexagonal and a little longer than broad. On either side of them lie three rows containing respectively fourteen plates reaching the antipenultimate pair of supero-marginals, six plates reaching the third supero-marginal, and three plates reaching the proximal edge of the second supero-marginal.

The membrane is thick and the outlines of the plates are, in consequence, hard to make out. The granulation is uniform, but the centre of about ten of the carinals, five of the first laterals and two of the second laterals is occupied by a smooth low boss, the diameter of which is about half that of the plate on which it stands. Where these bosses are absent there is often a low valvate pedicellaria, flush with the granules surrounding it, near the centre of the plate. The pores occur everywhere except between the plates lying on either side of the interradial line. They are rather few around the central plates, about ten in number around the proximal radial plates, and about six in number around the distal radial plates.

There are nine tumid *supero-marginal plates*. A pair occupies the apex of each interbrachial arc. These two are broader than long. At the base of the ray the plates are square, but towards the tip of the ray they become broader than long again, as is shown by the following measurements :

	Plate No.			
	1.	3.	5.	7.
Height	1·75	1·5	1·25	1 mm.
Length	1·75–2·5	2·75	2·5	1·75 mm.
Breadth	3·5	2·75	2·5	2·5 ,,

The granulation of the plates is very characteristic. At the edge of each plate there are about four rows of closely crowded granules, narrower but longer than those of the abactinal area. In the next two or three rows the granules are larger, and then the greater portion of the centre of the plate is occupied by about five rows of vast polygonal plate-like granules fitting together in a close mozaic.

The *infero-marginal plates* correspond to the supero-marginals, but are not tumid. The lateral face bears very large polygonal granules like those of the supero-marginals, but on the actinal face the granules are not so large and they show a tendency to imbricate.

The *actinal intermediate areas* are paved with plates lying in three chevrons, of which the outermost encloses a few odd plates. Successive chevrons contain 12, 6 and 3 plates,

and the innermost extends to the fourth infero-marginal. The granulation is uniform, coarser than that of the abactinal surface, and the granules are very slightly overlapping. Low valvate pedicellariæ are found on many plates, particularly those of the innermost chevron.

The actinal face of the *adambulacral plates* is covered with granules a little finer than those of the actinal intermediate plates, and the pedicellariæ, where they occur, are also a little smaller. As in the genus *Stellasteropsis*, the furrow spines form a continuous palisade, roofing in the furrow.

REMARKS.—Close to but not identical with this form is a specimen in the British Museum bearing the label: *Goniodiscus* sp. (yg), 63. 11. 19. 19. Mozambique. Dr. Livingstone.

Projecting from a hole about 5 mm. from the anus of this specimen is the tip of a Gasteropod shell.

AFFINITIES.—The single row of spines on the adambulacral plates and the character of the granules on the supero-marginal plates place this specimen beyond doubt in the genus *Monachaster* Ludwig (1916, p. 412). It may be distinguished from the only other known species *M. sanderi* (Meissner) by the following characters: (i) *M. umbonatus* has slightly longer arms and more supero-marginal plates; (ii) the supero-marginal plates of *M. umbonatus* have no tubercles such as those of *M. sanderi*; (iii) the granulation of the abactinal plates of *M. umbonatus* is uniform: in *M. sanderi* larger granules are found round the pores.

Genus *Anthenoides* Perrier.

The distribution of the eight species belonging to this genus is as follows:

Ocean.	Species.	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic	*piercei* Perrier	Perrier, 1884	3	1	West Indies	153 m.	..
		Verrill, 1915	Many		,, ,,	108–829 m.	Sand and shells; grey sand; hard ground.
Pacific	*epixanthus* Fisher	Fisher, 1906	..	..	Hawaii	333–486 m.	Various.
Eastern Archipelago	*granulosus* Fisher	,, 1913	6	3	Moluccas	480 m.	Grey mud; fine sand.
		Döderlein, 1924	2	2	Bali Sea	289–330 m.	Mud.
	lithosurus Fisher	Fisher, 1913, 1919	1	1	China Sea	380 m.	Grey mud and sand.
	rugulosus Fisher	,, ,, ,,	14	7	Philippines	375–700 m.	Green mud and ooze.
	cristatus (Sladen)	Sladen, 1889	..	1	,,	182 m.	Green mud.
		Fisher, 1919	88	14	,,	182 m.	Green mud; sand; rock; globigerina ooze.
Indian	*sarissa* (Alcock)	Alcock, 1893	..	..	Andaman Is.	230–456 m.	..
	marleyi Mortensen	Mortensen, 1925	1	1	Natal	..	..

A key to the known species is given by Fisher (1919, p. 329).

Anthenoides marleyi Mortensen.

Anthenoides marleyi, Mortensen, 1925, p. 149, pl. viii, figs. 1, 2, text-figs. 2, 3, 4.

Occurrence :

St. 106, Zanzibar Channel, 183–194 m., green mud ; 9 specimens.

Description.—The dimensions of the specimens are : R 70–108 mm., r 26–38 mm., R/r 2·6–2·8.

The *abactinal surface* is paved with flat polygonal plates, covered with granules, of which one, or occasionally two, or even three, are conspicuously enlarged.

The *supero-marginal plates*, which number twenty-two to twenty-five, are rounded and form a broad border to the abactinal surface. They are covered with granules, of which three or four are enlarged, one usually more than the rest. Two or three valvate pedicellariæ also occur on most of the supero-marginal plates. The *infero-marginal plates* correspond to the supero-marginals. On the lateral edge of the proximal plates are found four to six flattened truncate spinelets, which are 1–2 mm. long and are arranged in two rows or irregularly. This armature extends at least half-way down each arm. The actinal surface of the plates bears a number of small, well-spaced granules which decrease in size towards the inner border.

The *actinal intermediate plates* are covered with small granules. All the plates of the innermost chevron and a few of the others bear an elongate valvate pedicellaria. On the remaining plates one to five of the granules are enlarged.

The *adambulacral plates* bear six to eight furrow spines. On the proximal edge of the actinal surface of each plate stands an elongate valvate pedicellaria, and distal to it one, or more usually two, large flattened spines about 2·5 mm. long.

Colour.—Actinal surface, white ; abactinal surface, white with a fine reticulation of carnelian red between the plates. In spirit the specimens are yellowish.

Remarks.—There are two minor features in which the present specimens differ from the description of the type : (i) the type has two or three spinelets on the edge of the infero-marginal plates, while on the actinal surface stand " some irregular elevations, having the appearance of worn-off tubercle bases, which, however, they are evidently not " (Mortensen, *loc. cit.*). The lower row of infero-marginal spines on the present specimens do encroach on the actinal surface of the plate to some extent, but they resemble the spines of the upper row ; (ii) the type has generally but one actinal adambulacral spine co-existent with a single pedicellaria, whereas the present specimens have commonly two. In both these features the specimens recall the Philippine form, *A. cristatus* (Sladen), which is, however, easily distinguished by its round, papilliform pedicellariæ. Mortensen regards *A. marleyi* as being related to the Atlantic form *A. piercei* Perrier. It would stand next this form in Fisher's key (1919, p. 328). The differences are that *A. piercei* possesses no enlarged supero-marginal granules, and on the actinal face of its adambulacral plates there are no pedicellariæ, but three spines all shorter than the furrow spines.

Anthenoides cristatus (Sladen). (Pl. III, fig. 5, Pl. V, fig. 1.)

Leptogonaster cristatus, Sladen, 1889, p. 327, pl. liv, figs. 1–7.
Anthenoides cristatus, Fisher, 1919, p. 329, pl. 78, figs. 1, 2, pl. 88, fig. 1, pl. 89, fig. 1.

Occurrence :

St. 194, Gulf of Aden, 220 m., sand ? ; 495 specimens.

Distribution.—Philippines, 182 m. ; Gulf of Aden.

Remarks.—This large collection is singularly uniform in size, the range of major radial measurement being 27–60 mm., while the R/r ratio varies between 2·3 and 2·7. The major radius of over 90% of the total number of specimens falls between 30 and 40 mm., and only seventeen examples are larger than 50 mm. The dimensions of these specimens are :

R .	60	59	59	58	57	56	54	53	53	52	52	51	51	50	50	50	50 mm.
r .	25	26	26	22	25	25	25	23	23	20	21	23	22	23	22	21	21 ,,
R/r .	2·4	2·3	2·3	2·6	2·3	2·3	2·2	2·3	2·3	2·6	2·5	2·2	2·3	2·2	2·3	2·4	2·4

The main description is taken from the smaller specimens with R 30–40 mm., as it is believed that this will be more valuable for subsequent comparison ; features characteristic of the larger series of specimens (R 50–60 mm.) are mentioned.

Description of Smaller Forms.—(i) *Arrangement of abactinal plates.*—The abactinal surface is covered with a thick membrane, and in order properly to investigate the arrangement of the plates it is necessary to boil the specimen in potash. For this reason a comparison of many specimens is not possible. Drying, however, reveals the plates more clearly, and from a number treated in this way, two (both have R 33 mm., r 14 mm.) which appeared to lie at either end of the range of variation were selected and boiled in potash. The first specimen has twenty-eight *carinal plates*, decreasing regularly in size from about the third plate to the tip of the ray. On the disk the plates are hexagonal with the edges rounded, and rather broader than long ; at the base of the arms they become more regular in shape, and the distal six or so, which lie between supero-marginals only, are longer than broad. They extend to the penultimate, or antipenultimate, pair of supero-marginals. On either side of each of the first nine carinals, separating them from the plates of the first lateral row, are two small secondary plates. A pore lies on either side of these plates, so that each carinal in this region is surrounded by six pores. The tenth to fifteenth carinals, being in direct contact with the plates of the first lateral row, are surrounded by only four pores. Beyond this level, the ninth supero-marginal plate, the pores cease.

The plates of the *first lateral* row are a little smaller than the carinals but resemble them in shape, in the regular decrease in size and in the elongation of the last few. Near the centre of the disk there are two or three secondary plates separating the first and second lateral rows, but most of the plates in these two rows are contiguous. Twenty plates reaching the tenth supero-marginal make up the first, thirteen similar but slightly smaller plates, reaching the sixth supero-marginal, make up the second lateral row and there are, besides, three rather irregular rows of plates. The initial plates of these five rows are a little larger than the rest and lie in pairs on either side of the interradial line, forming a distinct landmark, which is rendered more conspicuous by the fact that the adjacent faces of the plates are the only areas of the disk where papulæ are not found.

The second specimen has secondary plates on either side of the first fifteen carinals, and between the first six plates of the first and second lateral rows. A few secondary plates may also be seen between the plates of the other rows.

(ii) *External features.*—The following description is taken from all the smaller specimens. The *abactinal surface* is covered with a thick membrane. On each plate, lodged superficially in this membrane, there are a few scattered granules. About fifteen small ones lie near the periphery, while in the centre there are one or, on the larger plates, two, occasionally three, or even more granules, five to six times as large as the others. On a small number of specimens pedicellariæ are found. These are either of the elongate type figured by Sladen (1889, pl. liv, fig. 6), or of the truncate type described by Fisher (1919, p. 331). The *supero-marginal plates* number fifteen to seventeen. The abactinal surface of the first three or four plates slopes downwards slightly, that of the remaining plates lies horizontally, then sweeps round in a broad curve which flattens out to form a lateral face to the plate, set at an acute angle to the abactinal face so that in transverse section the arm is slightly concave. The height of all the plates is small, the first three are broader than long, the fourth square, and the remainder longer than broad. The granulation is like that of the abactinal plates. Approximately forty of the small granules lie in two indefinite rows near the periphery of the plate, and about half-a-dozen of the larger lie nearer the median line. On the sixth plate, or thereabouts, one of these comes to lie on the outer distal corner, where it projects as a conspicuous papilla visible on all the rest of the plates of the arm.

The *infero-marginal plates* correspond to the supero-marginals, and like them are all low. They form a massive rounded border to the intermediate areas, arching up well above the general level of the actinal surface. The breadth here is nearly twice the length, but it falls off rapidly along the arms and at the tip of the ray is less than the length. The lateral face of the first three to five plates bears two to five slightly pointed, round-tipped or truncate spines about 1 mm. long, while most of the plates of the arm bear a single spine which comes to lie on the outer distal corner, and diminishes rapidly in size on successive plates till it is no more than a granule.

The *actinal intermediate areas* extend to the fourth or fifth infero-marginal. The plates are diamond-shaped and overlapping. They fall into four clearly marked chevrons, the outermost enclosing a group of about three plates. The innermost chevron contains nine to twelve plates, the second to fourth chevrons about 7, 5 and 3 plates respectively. The granulation is similar to that of the abactinal and marginal plates, but the smaller granules, which are very widely spaced and number barely twenty on the largest plates, are found all over the surface of the plate and are not confined to the neighbourhood of the periphery. A single large granule stands near the centre of most plates. Two papilliform structures are seen on nearly every plate of the innermost chevron. One is usually a granule, the other a pedicellaria ; but the two are very hard to distinguish.

The *adambulacral plates* have a radiating series of four to six cylindrical or slightly flattened furrow spines, tapering at the extremity to a rounded tip and united by membrane at the base. The relative size is variable, for the two outermost may be of the same size as the rest, or so small as to be little more than granules. The remaining spines are usually subequal, but one or two in the centre may be longer than the rest. Close to the furrow spines, and near the proximal border of the plate, stands a two-jawed pedicellaria about half as long as the central furrow spine. Towards the distal border of the plate

and nearer the outer edge there is a single spine about as long as the pedicellaria but considerably more robust than a furrow spine. This spine becomes larger on successive plates, and on those which lie beyond the limits of the actinal intermediate plates it is longer than the furrow spines. In most specimens a certain number of the proximal plates bear a row of three smaller spines in place of the single one.

Description of Larger Specimens.—(i) *Arrangement of abactinal plates.*—Two specimens (R 51 and 58 mm.) were boiled. The smaller has thirty-six carinals, reaching the antipenultimate pair of supero-marginals, with a pair of secondary plates on either side of the first twelve ; and twenty-six first lateral plates, reaching the thirteenth supero-marginal, with a single secondary on the outer side of the first eight. There are seven more rows of plates between which a very occasional secondary is to be found. Papulæ are found all round the initial plates of the two outermost rows. This feature is not general, but is seen again in one or two of the other large specimens.

The second specimen shows exactly the same features, namely a well-developed adradial row of secondary plates, a poorly developed series between the first and second lateral rows of plates, and only an occasional one between the plates of the other rows.

(ii) *External features.*—The granulation of the *abactinal plates* is identical with that of the smaller specimens. Pedicellariæ occur on fourteen out of the seventeen specimens ; the largest number on one specimen is twenty-five. The *supero-marginal plates* number eighteen to twenty-two. In the interradius the *infero-marginals* project beyond the supero-marginals. Two to four spines are found on as many as the proximal ten infero-marginals. They attain a length of 2 mm.

There are five chevrons of *actinal intermediate plates*, the innermost containing fourteen to nineteen plates and reaching the seventh to ninth infero-marginal. As a rule each plate bears one large and about twenty small granules, but there may be more than one large granule and sometimes the granules are evenly graded in size.

The *adambulacral plates* bear four to six furrow spines. In all the larger specimens at least two or three plates have a row of three spines on the actinal surface, but in many of the specimens there are one or more ambulacra bordered by plates of which every one bears but a single actinal spine. The presence of one or three spines on the actinal surface of the adambulacral plates would seem to be a variable character and not a sound foundation on which to base a specific distinction.

Affinities.—This series of specimens differs from previous descriptions of *A. cristatus* (Sladen) in the following minor features : (i) the R/r ratio is slightly smaller ; (ii) the size is smaller ; of nearly five hundred specimens the largest has R 60 mm., whereas Fisher (1919, p. 329) records a specimen of R 110 mm. from a collection of eighty-eight ; (iii) large and small granules are found on nearly all the plates. The type is uniformly granulated.

In his key Fisher (1919, p. 328) separates *A. cristatus* from Alcock's Andaman species *A. sarissa* thus :

Proximally two or three subambulacral spines or prominent pedicellariæ, abactinal pedicellariæ *cristatus.*
Proximally one subambulacral spine, no abactinal pedicellariæ . . . . *sarissa.*

The present series of specimens shows that the number of subambulacral spines is not a reliable character. Further, abactinal pedicellariæ were absent from three out of seventeen specimens with a major radius of more than 50 mm., and from the majority of

the smaller ones, and, as Alcock's specimen had R 44 mm., this character also must be discarded. Alcock, however, remarks that small plates are inlaid everywhere between the larger ones, and if this be so, it is too great a difference to be ignored and the two species must be regarded as distinct. The Indian Museum sent for comparison a specimen labelled "*Anthenoides sarissa*", but unfortunately it proved to be a young *Oreaster*.

Immature *Goniasteridæ*.

Occurrence :

St. 45, Arabian coast, 38 mm., Lithothamnion ; 4 specimens.

One (R 5 mm.) is perhaps an *Astroceramus*, two (R 5 and 4 mm.) are possibly *Anthenoides*. The fourth and largest (R 10 mm., r 7 mm.) is an interesting form which, as far as I can discover, is unlike any species previously known from the area. It has the following characters : The *abactinal plates* are circular, arranged in regular rows, and bordered with rather large hemispherical granules ; the centre of each plate is occupied by a single granule about twice the size of those round the edge. The *supero-marginal plates,* of which there are four, have a similar border but are naked centrally. The first two are oval, longer than broad, and lie at an angle to the abactinal surface. These are followed by what appears to be a rudimentary plate, and then comes a large tumid plate, twice the size of the first.

There are five *infero-marginal plates* showing a regular decrease in size from the interradius to the tip of the ray. Besides a border of granules similar to that of the supero-marginal plates, each one bears a tubercle on the outer distal corner, and these tubercles increase in size as the tip of the ray is approached. Plates are found between the marginals.

There are four chevrons of *actinal intermediate plates,* the innermost attaining the tip of the ray. Each plate is armed with two rows of three or four hemispherical granules, of which one in the centre of the plate is larger than the rest.

The *adambulacral plates* have four rather short round-tipped furrow spines and two rows of three or four granules on the actinal surface. One of the granules in the centre of each row is elongated, the elongation being more marked in the inner row.

The form of the granulation suggests that the example belongs to the genus *Hippasteria,* though the typical valvate pedicellariæ are absent and the enlarged last pair of supero-marginals is not usual in this genus.

Family Oreasteridæ.

Genus *Oreaster* Müller & Troschel.

Oreaster hiulcus Müller & Troschel.

Oreaster hiulcus, Müller & Troschel, 1842, p. 48.

Occurrence :

St. 53, Arabian coast, 13·5 m., rock, shingle, shells and Lithothamnion ; 2 specimens.

Distribution.—Indian Ocean.

Colour.—Abactinal tubercles, nopal red ; abactinal surface, a little darker than the tubercles ; actinal surface, white with a faint purplish tinge ; furrow spines, white ; infero-marginal spines, strawberry pink ; tube feet, orange cinnamon.

Oreaster sp. juv.

Occurrence :

St. 45. Arabian coast, 38 m., Lithothamnion ; 6 specimens.

Remarks.—The largest specimen measures R 11 mm., r 6 mm., the smallest R 7 mm., r 3·5 mm.

Family Linckiidæ.

Genus *Nardoa* Gray.

Nardoa faouzii sp. n. (Pl. I, figs. 8 and 9.)

Occurrence :

St. 53, Arabian coast, 13·5 m., rock, shingle, shells and Lithothamnion ; 1 specimen.

Diagnosis.—R/r 5·3. Disk small, scarcely elevated above the level of the arms ; with two rings of abactinal plates. Arms cylindrical, the actinal surface flattened ; distal third tapering to a blunt tip ; proximal quarter of ray with seven rows of almost flat abactinal plates in regular longitudinal and transverse series ; plates of carinal and first lateral rows rather irregular in arrangement on second quarter of ray, quite irregular beyond middle, where they are round but no smaller till quite near tip of ray ; plates of second lateral row reaching tip of ray in fairly regular line ; plates of third lateral row reaching middle of ray in regular line. Marginal and actinal plates in regular series throughout ray. All plates covered with close granulation, which, except on actinal plates, becomes finer towards the periphery of each plate. Papulæ in groups of six between abactinal plates, ten between marginals and seven between infero-marginal and actinal plates. Adambulacral armature in three series ; four or five furrow spines ; three large granuliform inner actinal spines and an outer row of four or five enlarged granules.

Description.—R 53 mm., r 10 mm. Two rings of plates surrounding a single central plate pave the abactinal surface of the *disk*. In the inner ring there are five large round radial plates, each about the size of the central plate, 3 mm. in diameter, and five small interradial plates less than 1 mm. in diameter. The outer ring also contains ten plates, five radials equal in breadth to the radials of the inner ring, but shorter owing to the fact that the distal edge is flattened, so that the plates are D-shaped ; and five interradials equal in size to the radial plates of the inner ring.

Co-serial with the radials is a line of quadrangular *carinal plates*, some 2 mm. broad by 1·5 mm. long. On either side of it lies a row of similar plates ; below this is a row of slightly smaller plates, and below this again a row of distinctly smaller plates, measuring about 1·5 by 1·25 mm. This regular arrangement is only found at the base of the ray and beyond is gradually lost. Thus of the carinal row the first four or five plates are arranged in a straight line, the next four or five are arranged less regularly, and beyond them, that is beyond a point about midway down the arm, the arrangement is quite irregular and the plates are round, without, however, showing any decrease in size till within about 5 mm. of the tip of the ray. Of the next, the first

lateral row, the first seven plates are in a straight line, the next eight in a rather irregular line, and the rest are arranged quite irregularly. The second lateral row extends in a more or less regular series to the tip of the ray, while the third, comprising some eighteen plates, extends in a regular line to the eleventh supero-marginal, where it disappears.

All the abactinal plates are only very slightly convex. Many have been rubbed bare, but those still undamaged show a close covering of hexagonal granules, which, near the periphery of the plate, are smaller and indistinguishable from those which cover the papular areas. Space is made for these by the rounding of the corners of the plates and in each one there are about six pores.

There are twenty-six *marginal plates* forming a distinct and regular series down the length of each arm. The first two supero-marginal plates are twice as high as broad, and the rest are square. The third plate measures 2 × 2 mm., and the remainder show a regular diminution in size to the tip of the ray. The granulation of the supero-marginals is similar to that of the abactinal plates. The infero-marginal plates lie directly below the supero-marginals and resemble them closely in size and granulation. Some ten pores occur in the areas between the marginal plates and seven in the areas between the infero-marginals and the actinal plates.

At the base of the ray there are three rows of *actinal plates*, the outermost of two, the middle of five, while the innermost extends to within 5 mm. of the tip of the ray. The plates, which decrease regularly in size, are broader than long, and the granulation becomes coarser towards the adambulacral border.

The *adambulacral plates* bear on a straight furrow margin four spines which are wedge-shaped in transverse section, and three times as long as broad; many bear also on the proximal side of these four a fifth smaller spine which is set back out of line with the rest. Outside the furrow series there is a row of three square truncate spines barely twice as long as broad. A third series of four or five is hardly to be distinguished from the granules of the actinal plates.

Affinities.—The regular arrangement of the first few abactinal plates is stated by Koehler (1910, p. 162) to be a feature of the young forms of *Nardoa lemonnieri*. *N. faouzii* is close to this species but may be distinguished at once by the abactinal plates, which are of much the same size almost to the tip of the ray. In *N. lemmonieri* they become small and elongated on the distal half of the ray. Two other closely related forms, *N. novæ-caledoniæ* Perrier and *N. mollis* Lütken, may be distinguished by the characters of the abactinal plates.

I have much pleasure in naming this species after Dr. Hussein Faouzi, Director of the Egyptian Fisheries Research Laboratory, and my colleague on the expedition.

Genus *Narcissia* Gray.

Narcissia mohamedi sp. n. (Pl. I, figs. 2 and 10.)

Occurrence:

St. 24, Gulf of Aden, 73–200 m., coarse sand, shell, ? rock; 1 specimen.

St. 157, Maldives, 229 m., coral rock; 1 specimen.

Diagnosis.—R/r 6·8. Disk large, paved with two rings of abactinal plates. Arms long; proximally with abactinal and actinal surfaces flattened; cross section about half, way down, round; tapering from a broad base to a fine pointed tip; abactinal surface

with three regular rows of plates ; lateral surface occupied by small plates in five irregular rows which rapidly become fewer distally. Supero-marginal plates rectangular ; in regular series bounding actinal border of lateral surface of arm. Infero-marginal plates similar ; confined to actinal surface. Actinal plates in four rows ; the three outermost short, innermost extending nearly to tip of ray. Adambulacral plates with five furrow spines, and on actinal surface an inner row of five short spines and an outer row of five granules. Whole surface with uniform miliary granulation. Papulæ in groups of four or five, only between abactinal and lateral plates.

Description.—The dimensions of the two specimens are R 95 mm., r 14 mm., and R 39 mm., r 6 mm. The arms are broad at the base, and a transverse section shows that the actinal surface is quite flat, and that the abactinal surface is also flattened to some extent. They taper rapidly, and distal to a point near the middle they are quite round in transverse section.

The centre of the *disk* is occupied by a hexagonal plate, 4 mm. in diameter, with the anus and two small plates lying to one side of it. Around this group of plates lies a ring consisting of five radials and five interradials, the radials a little smaller than the central plate, the interradials a little smaller than the radials. Outside this ring there are five radial plates similar to those of the inner ring and five groups of interradial plates. The arrangement of the plates in these groups is variable, but typically there is a larger plate on the interradial line with two smaller ones on either side.

From the radials of the disk to the tip of the ray runs a straight line of *carinal plates*, those at the base some 1·75 mm. long and 2 mm. broad, the rest showing a uniform diminution in size. On either side is a row of similar but narrower plates. This row sweeps round the interradial angle on the abactinal surface of the disk in a continuous band, isolating the groups of interradial plates mentioned above in a small triangular area. A small madreporite, about 1·5 mm. in diameter lies at the apex of one of these bands.

Forming the sides of the ray and disk but encroaching a little on to the abactinal surface, especially of the disk, is an area occupied by irregularly hexagonal plates about 1 mm. in diameter and arranged in five ill-marked series, which decrease rapidly in number so that half-way down the ray there are only two, and 4 mm. from the tip of the ray the single persisting row disappears.

The *supero-marginal plates* form a regular series bounding the actinal edge of the lateral surface of the ray. The plates are rectangular, those at the base of the ray 2 mm. long by 1·75 mm. broad, the rest decreasing progressively in size to the tip of the ray. The *infero-marginal plates* lie on the actinal surface and resemble the supero-marginals in size and shape.

Four rows of *actinal plates* are found at the base of the ray. The outermost contains four plates, reaching the second infero-marginal ; the next contains ten, reaching the fifth ; the next contains twenty, reaching the tenth infero-marginal, while the innermost row extends to within a few millimetres of the tip of the ray.

The entire surface of the animal is covered by a fine uniform miliary granulation, interrupted only by sulci which run transversely between the actinal and marginal plates, and, of course, the *pores*. Four or five of these are found at the corners of the abactinal and lateral plates, but they do not occur below the level of the supero-marginals. Between the carinal and first lateral rows of plates the pore-fields are nearly confluent.

The *adambulacral plates* bear on the furrow margin, which is slightly convex and also, owing to the fact that the inner half of each plate slopes down towards the furrow, sunk below the level of the rest of the plate, five flattened truncate spines, about 1 mm. long and 0·2 mm. broad. Actinally there is a row of five subquadrate truncate spines about half the length of the furrow spines, though in surface view they appear equal in height owing to the slope of the plate. Outside them stands a row of five angular granules.

The description is taken from a fine specimen from the Gulf of Aden, entire except for one arm, which is in process of regeneration. A smaller specimen from the Maldives, having R 39 mm., is almost certainly the same species. It differs in having only two or three pores per field, with the fields well separated, and at the base of the ray there are only three rows of lateral plates.

Affinities.—The tapering rays, the papulæ confined to the abactinal surface and the adambulacral armature are all features which characterize the genus *Narcissia*. On the other hand the present species lacks the carinate, triangular rays, which are found in the other members of the genus.

This species is named after Abdul Fateh Mohamed Effendi, of Cairo University, a member of the chemical staff of the expedition.

Genus *Ophidiaster* Agassiz.

Ophidiaster purpureus Perrier.

Ophidiaster purpureus, Perrier, 1869, p. 61.

Occurrence :

St. 157, Maldives, 229 m., coral rock ; 1 specimen.

Distribution.—New Ireland, Moluccas, Amboina, Maldives, Seychelles, Mauritius, Zanzibar.

Genus *Linckia* Nardo.

Linckia multifora (Lamarck).

Asterias multifora, Lamarck, 1816, p. 565.
Linckia multifora, Lütken, 1871, p. 276.

Occurrence :

St. M.B. 1 (*b*), Red Sea, 29 m., sand, shell and coral ; 1 specimen.
St. M.B. 1 (*d*), ,, ,, 26 m., ,, ,, 2 specimens.

Distribution.—Widely distributed in Indo-Pacific region.

Order SPINULOSA.

Family Asterinidæ.

Genus *Paranepanthia* Fisher.

Paranepanthia brachiata (Koehler).

Nepanthia brachiata, Koehler, 1910, p. 133, pl. xix, figs. 14 and 15.
Paranepanthia brachiata, Fisher, 1919, p. 420.

Occurrence :

St. 24, Gulf of Aden, 73–200 m., coarse sand and shell ; 1 specimen.
St. 43, Arabian Coast, 83–100 m. ; 4 specimens.
St. 45, ,, ,, 38 m., Lithothamnion ; 3 specimens.
St. 70, Gulf of Oman, 196 m., green mud ; 1 specimen.

Distribution.—Andaman Sea ; Gulf of Aden, Arabian Sea, Gulf of Oman.

Remarks.—The five specimens from Sts. 43 and 70 have been compared with Koehler's type from the Andaman Sea. All are smaller, having a major radius of about 25 mm., but otherwise they closely resemble the type. The four specimens from Sts. 24 and 45 probably belong to this species but they are all minute and certain identification is not possible.

Family Echinasteridæ.

Genus *Henricia* Gray.

Henricia sp.

Occurrence :

St. 24, Gulf of Aden, 73–200 m., coarse sand and shell ; 5 specimens.

Remarks.—The largest specimen of the five has R 43 mm., r 7 mm., the smallest R 36 mm., r 6 mm. The arms are round abactinally, flat actinally, and taper very gradually to a rounded tip.

The *abactinal plates* are small and the pits enclosed by them large, nearly 1 mm. in diameter. Small square plates occur in the pits and may stand between two pores, though it is usual to find only a single pore at the bottom of each pit. The plates are beset with two or three rows of spinelets, which are very fine, pointed, and invisible to the naked eye. There are about twenty on each plate.

Two rows of *marginal plates* can be traced to the tip of the ray. The *supero-marginal plates* are oval, broader than long, and some show two divergent articulating processes at the distal end. The *infero-marginal plates* correspond to the supero-marginals and are rectangular, twice as broad as long. The marginal plates are beset with about four rows of spinelets similar to those of the abactinal plates. Pores are not found between or below the marginals.

There is an inner row of *actinal plates* which correspond exactly with the infero-marginals. At the base of the ray the plates are twice as broad as long, but they become square, and about half-way down the ray the series comes to an end, the

last few plates being twice as long as broad. An outer row of plates extends for about 5 mm. The furrow margin of the *adambulacral plates* is angular. A single spine occupies the apex, while two similar spines stand on either side. Outside stands another row of three spines of the same size. The rest of the actinal surface of the plate is covered with three or four more rows of spines, which decrease in size till they are uniform with those of the rest of the body. Within the furrow the apex of the plate bears three fine upcurved spines.

Fisher issues several warnings about the difficulty of identifying the species of this genus, even with material for comparison. None exists from the locality whence these examples come, and, since all are young, the application of a specific name might, perhaps, lead only to subsequent confusion ; but I would suggest that they are near to the sub-antarctic form *H. præstans* (Sladen).

Henricia sp.

Occurrence :

St. 105, Zanzibar area, 238–293 m., green mud ; 5 specimens.

Remarks.—The largest has R 30 mm., r 4 mm. ; the smallest R 20 mm., r 3 mm. The rays are more pointed than those of the specimens described above, the abactinal plates larger relative to the papular pits, and the spinelets on the plates a little coarser. The marginal and adambulacral plates are similar to those of the specimens described above, but pores occur both between the marginals and between the infero-marginals and the actinal plates.

Genus *Dictyaster* Alcock & Wood-Mason.

Dictyaster sp.

Occurrence :

St. 54, Arabian coast, 1046 m., green mud ; 1 specimen.

Remarks.—A single small specimen (R 19 mm., r 9 mm.) belongs perhaps to this genus. Compared with the description of *D. xenophilus* Alcock (1893), the arms are shorter and broader at the base. Further, the specimen has but a single furrow spine on all the plates except the first, which has two, while in *D. xenophilus* there are three on the proximal and two on the remaining plates. Both these differences may be due to the difference in size.

Family Acanthasteridæ.

Genus *Acanthaster* Gervais.

Acanthaster ? mauritiensis de Loriol.

Acanthaster mauritiensis, de Loriol, 1885, p. 6, pl. xii, figs. 1–3.

Occurrence :

St. 53, Arabian coast, 13·5 m., rock, shells, shingle and Lithothamnion ; 1 specimen.

Distribution.—Indian Ocean.

Description.—R 74 mm., r 35 mm., arms 14, madreporites 10. The abactinal surface of the disk is covered with short, bluntly pointed spines, 2 to 4 mm. in length, each with at least half the shaft covered by a granular investment. On the arms the spines, which are set on irregular ridges, are more robust, up to 5 mm. in length. There is a series of rather blunt marginal spines, 4 to 5 mm. in length. Above it there is a ridge whereon the spines are irregular in size and distribution, though not in alignment. Below the marginal series there are three rows of spines, each 2 to 3 mm. long, with granules only about the base. The innermost of these three is the subambulacral series. There are four or five furrow spines, the inner two or three usually twice as long as the two outermost.

Colour.—Actinal surface and tube feet, pale olive buff; abactinal surface, pale purplish grey becoming purplish grey towards the tips of the arms; spines, nopal red, those of the actinal surface a little lighter. These colours are little changed in the preserved specimen.

Remarks.—This example is too young for a specific name to be applied with certainty, though it is probably *A. mauritiensis*. De Loriol had a number of specimens at his disposal, and mentions that among the smaller ones, one of 150 mm. diameter had the longest spines 7 mm. long, while most measured between 4 and 5 mm. These figures are a little larger than those of the present specimen, but the discrepancy does not seem great enough to be significant. *A. planci* (Linnæus) (including *echinites*), *A. ellisii* Gray and *A. solaris* Gray have spines longer than those of *A. mauritiensis*, while *A. brevispinus* Fisher has them shorter.

Family Pterasteridæ.

Genus *Pteraster* Müller & Troschel.

Pteraster obesus Clark.

Pteraster obesus, H. L. Clark, 1908, p. 282.

Occurrence :

St. 157, Maldives, 229 m., coral rock ; 3 specimens.

St. 177, Gulf of Aden, 274–366 m., green mud and rock ; 1 specimen.

Distribution.—Sagami Bay, Japan, 140 m. ; Maldives, Gulf of Aden.

Genus *Retaster* Perrier.

Retaster sp.

Occurrence :

St. 27, Gulf of Aden, 37–91 m., sand and shells ; 1 specimen.

Description.—R 15 mm., r 6 mm., R/r 2·5. The arms are round and taper gradually to a blunt upturned tip.

The plates of the abactinal surface have a four-rayed base, a vertical column and, surmounting this, four radiating hyaline spines supporting a delicate transparent membrane traversed by opaque white muscle bands. These are regularly arranged ; four main

bands radiate from each column and there are often several subsidiary smaller ones as well. In each of the triangular areas, bounded by these bands, some half-dozen pores occur.

There are three adambulacral spines in a transverse series. The spines are hyaline, and are connected with each other and with the actino-lateral spine, which is four to five times as long, by a membrane extending almost to the tip of each spine. The actino-lateral spines are also joined by a longitudinal membrane, which, when lying flat, covers nearly the entire actinal surface of the animal.

The mouth plates bear a furrow series of five membrane-invested spines, which decrease in size progressively from the first. Actinally each plate bears a tapering hyaline spine as long as, but stouter than, the actino-lateral spines.

The specimen lies near *Retaster insignis* Sladen, a species well known from the Eastern Archipelago, but it is too small for definite identification.

Genus *Hymenaster* Wyville Thompson.

Hymenaster alcocki Koehler.

Hymenaster alcocki, Koehler, 1909, p. 110, pl. i, figs. 7, 8, pl. iii, fig. 8.

Occurrence :

St. 118, Zanzibar area, 1789 m., globigerina ooze ; 1 specimen.

Distribution.—Andaman Sea, 1175 m., 1 example ; Zanzibar.

Remarks.—The single specimen is small and in poor condition.

Hymenaster sp.

Occurrence :

St. 120, Zanzibar area, 2926 m., brown mud over grey globigerina ooze ; 2 specimens.

Remarks.—The specimens are too small to be referred to their proper species.

Order FORCIPULATA.

Family Zoroasteridæ.

Genus *Zoroaster* Wyville Thompson.

Zoroaster, Wyville Thompson, 1873, p. 154 ; H. L. Clark, 1920, p. 100 (distribution and key to known species) ; Fisher, 1919, p. 472 (key to Into-Pacific species).

Members of this genus abound in the Indian Ocean, and five species have been described by Alcock (1893, p. 108 *et seq.*) and one by Koehler (1909, p. 108). The expedition did not secure a large number of specimens, but those which were taken are in good condition. For the most part they closely agree with Alcock's descriptions and call for little comment.

Zoroaster alfredi Alcock.

Zoroaster alfredi, Alcock, 1893, p. 102.

Occurrence :

St. 81, Ras al Hadd, Arabia, 3351 m., grey clay ; 1 specimen.

Distribution.—Bay of Bengal, 2376–2522 m., globigerina ooze ; Arabian Sea.

Remarks.—Alcock describes this species as having the largest pedicellariæ—"as large as grape stones". The largest pedicellariæ of the present specimen, though of considerable size, are little over 2 mm. in length ; and a further difference lies in the presence of as many as five papulæ between the upper series of plates, whereas the type has three.

The colour of this specimen was not matched with colour standards, but was noted as "dirty white".

Zoroaster angulatus Alcock.

Zoroaster angulatus, Alcock, 1893, p. 105.

Occurrence :

St. 159, Maldives, 914–1463 m. ; 2 specimens.

Distribution.—Gulf of Manaar, 1074 m., green mud, Laccadive Sea, 1269 m., coarse coral shingle ; Maldives.

Remarks.—The dimensions of both specimens are : R 165 mm., r 12 mm., R/r 13·75.

Zoroaster sp. juv.

Occurrence :

St. 168, Central part of the Arabian Sea, 2937–3182 m., rock ; 1 specimen.

Remarks.—This, a four-rayed specimen, has the following dimensions : R 60 mm., r 6 mm., R/r 10.

Colour.—Actinal surface, salmon orange ; tube feet, dull indian purple ; abactinal surface, salmon orange with the disk and a broad irregular line down the arms, white.

Genus *Cnemidaster* Sladen.

Cnemidaster squameus (Alcock).

Zoroaster squameus, Alcock, 1893, p. 109.
Cnemidaster squameus, Fisher, 1919, p. 481.

Occurrence :

St. 185, Gulf of Aden, 2000 m., green mud ; 2 specimens.

Distribution.—Laccadive Sea, 1906 m., green mud ; Gulf of Aden.

Family Asteriidæ.

Genus *Sclerasterias* Perrier.

A revision together with an account of the distribution of this genus is given by Fisher, 1928, p. 107.

Sclerasterias mazophorus (Alcock & Wood-Mason). (Text-fig. 12.)

Asterias mazophorus, Alcock & Wood-Mason, 1891, p. 436 ; Alcock, 1893, p. 115.
Sclerasterias mazophorus, Fisher, 1928, p. 107.

Occurrence :

St. 35, Gulf of Aden, 457–549 m., green mud, sand and shell ; 1 specimen.

St. 194, Gulf of Aden, 220 m. ; 18 specimens.

Distribution.—Bay of Bengal ; Gulf of Aden.

Description.—The individuals are very uniform both in characters and size. The following description is taken from one of the best preserved specimens. R 50 mm., r 5 mm., R/r 10, greatest breadth of arm 8 mm. The arms are constricted at the base, broadest about a quarter of the way down, and from this point they taper to a rounded tip. They are rather flat, the height of an arm lying on its actinal surface being some 4 mm.

The *abactinal skeleton*.—The carinal plates (Text-fig. 12a) extend down the ray as a regular series of cruciform ossicles, of which approximately two in every three bear a pointed upright spine, some 2 mm. long and encircled about the base by a wreath of pedicellariæ. Between the carinals and the supero-marginals lie two ossicles (Text-fig. 12b and c), of which one or the other bears a radially directed articulating process which is very occasionally found to bear a spine. The two outer series of plates, the *marginals*, (Text-fig. 12d and e) lie at a steep angle and form the sides of the ray. The plates are roughly cruciform, with one arm, the external in the case of the supero-marginals and the internal in the case of the infero-marginals, longer than the others. Approximately every second supero-marginal plate bears a spine, similar to the spines of the carinals. Every infero-marginal plate bears two spines, the larger somewhat longer than the spines of the other plates and armed with pedicellariæ only on its abactinal surface, the smaller situated outside and below the larger, about half the size and unarmed. A web of membrane, particularly conspicuous near the base, runs along the side of the ray and unites the infero-marginal spines.

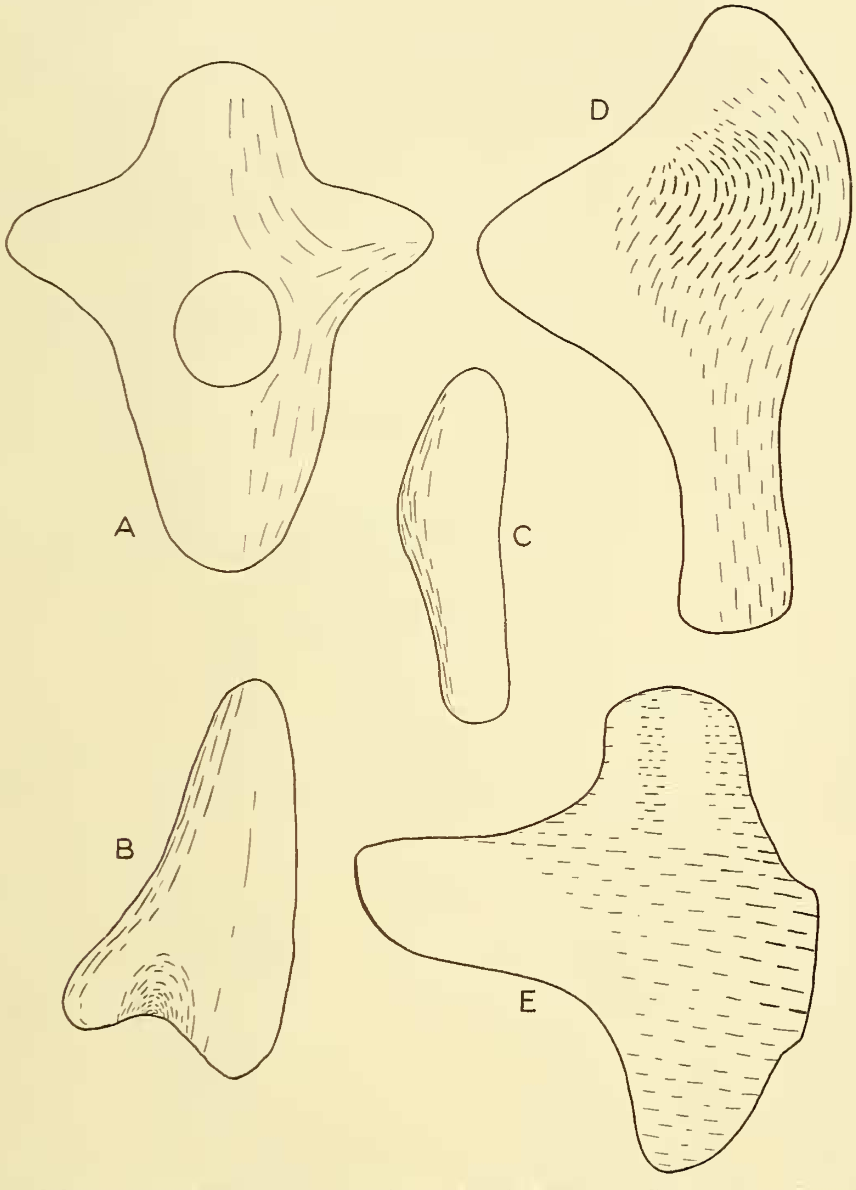
The *papulæ* lie in four rows, emerging in groups of four or five between the carinal, adradial, supero-marginal and infero-marginal plates, and singly between the infero-marginal and actinal plates.

The *furrow spines* are fine, straight-sided, truncate at the tip and articulated by a broadened base. There are two spines to a plate, the bases overlap and the proximal stands outside the distal spine.

Each *mouth plate* bears at the inner angle a round truncate incurved tooth, a trifle shorter but more robust than the adambulacral spines. Springing from near the base of this tooth is a shorter pointed spine, directed into the furrow. A large pedicellaria is

often associated with this spine. The abactinal surface of the plate bears a large round truncate spine, about equal in length to an adambulacral spine but stouter.

The abactinal membrane of the preserved specimens is of a reddish-brown *colour*. The actinal surface is white.



TEXT-FIG. 12.—*Sclerasterias mazophorus* (Alcock & Wood-Mason). (St. 194.) A, Carinal ossicle; B and C, Adradial ossicles; D, Supero-marginal ossicle; E, Infero-marginal ossicle.

AFFINITIES.—Three species, *Coscinasterias* (*Distolasterias*) *euplecta* (Fisher, 1906), from Hawaii, *Distolasterias hypacantha* (Fisher, 1907) from the Philippines, and *Eustolasterias stenactis* (H. L. Clark, 1925) from Natal are mentioned by Fisher (1928, p. 107) as "closely related and apparently small species or forms of a wide-ranging species". He suggests that all may ultimately prove to be races of *S. mazophorus*, *if* Alcock proves to be wrong in stating that spines occur on all the carinal and supero-marginal plates.

It is very unfortunate that, although I have had the opportunity to examine a specimen of *mazophorus* from the Indian Museum, I am not in a position to settle this point, as so many spines have obviously dropped off. A number of plates, however, lack any trace of a scar and give the impression that they have never borne a spine. Furthermore, the present specimens, which certainly do not bear spines on every carinal plate, agree closely with the example of *mazophorus* (not the type) from the Indian Museum. In fact the agreement is closer than the original description. This description seems to me to suggest that the infero-marginal spines bear a complete wreath of pedicellariæ, which is not the case, and the skeleton of the specimen sent was not as Alcock described it. The adradial series is composed of two distinct plates, one of which bears an articulating process directed longitudinally, and the infero-marginal plates have a long articulating process passing upwards and inside the articulating process of the supero-marginal. The skeleton is in fact identical with the specimens which are figured here.

It would seem therefore that the specimens collected by the expedition belong to the species *Sclerasterias mazophorus* (Alcock & Wood-Mason), and that, when it is possible to compare them with collections of *Sclerasterias euplecta*, *S. euplecta hypacantha* and *S. euplecta stenactis*, all will be found to be local races of a single widespread species, as is suggested by Fisher.

Family Brisingidæ.

Genus *Odinia* Perrier.

The genus is distributed as follows :

Ocean.	Species.	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic	*semicoronata* (Perrier)	Perrier, 1885	2	1	Coast of Africa (equatorial)	1056–1435 m.	Rock.
		Mortensen, 1913	..	..	Off Greenland	..	..
	americana (Verrill)	Verrill, 1880, 1885	1	1	Off Nova Scotia	320 m.	..
	robusta (Perrier)	Perrier, 1885	2	2	Coast of Africa (equatorial)	882–1435 m.	Rock.
		Koehler, 1895	..	1	Coast of France	1750 m.	..
		„ 1909*a*	1	1	Canary Is.	2165 m.	Globigerina ooze.
	elegans (Perrier)	Perrier, 1885	15	2	Coast of Africa (equatorial)	882–1435 m.	Rock.
	pandina Sladen	Sladen, 1889	..	1	Faero channel	800 m.	..
	antillensis A. H. Clark	Clark, 1934	2	1	West Indies	504–595 m.	..
Pacific	*pacificus* Fisher	Fisher, 1906	2	2	Hawaiian Is.	500–950 m.	Broken shells and gravel; fine grey sand and mud.
Eastern Archipelago	*penichra* Fisher	Fisher, 1916, 1919	1	1	Philippines	200 m.	Coarse grey sand.
	magister Fisher	„ 1917, 1919	1	1	„	..	..
Indian	*clarki* Koehler	Koehler, 1909	4	1	Maldives	837 m.	..
	austini Koehler	„ „	1	1	Off Ceylon	733 m.	..

Odinia austini Koehler.

Odinia austini, Koehler, 1909, p. 124, pl. iv, fig. 7* ; pl. xiii, figs. 5, 6.

Occurrence :

St. 152. Maldives. 609–915 m., green sand ; 1 specimen.

Distribution.—Ceylon : Maldives.

Remarks.—Koehler separates *O. austini* from *O. clarki* on the grounds that the former lacks furrow spines, actinal oral spines and pedicellariæ on the mouth spines. The present specimen has a disk diameter of 27 mm. and is larger than Koehler's example of *O. austini*. It lacks furrow and actinal oral spines, and therefore I have applied this name to it, but the spines on the border of the mouth plates are armed with pedicellariæ and it is thus to some extent intermediate between the two species. I feel, however, that more material is required before these two can be regarded as identical.

Colour.—Uniform coral red with furrows and actinal rim of the disk lighter. In spirit the specimen is white.

Genus *Brisinga* Asbjørnsen.

In 1917 Fisher (see also Fisher, 1919, 1928) revised the family *Brisingidæ*, and many species previously referred to the genus *Brisinga* were placed by him in newly erected genera. The distribution of the genus in the restricted sense is shown in the table below :

Ocean.	Species.	Reference.	Number caught.	Number of stations.	Locality.	Depth.	Bottom.
Atlantic .	*endacacnemos* Asbjørnsen	Many records. (Asbjørnsen, 1856 ; Dujardin et Hupé, 1862 ; Sladen, 1889 ; Brunchorst, 1891 ; Bell, 1892 ; Norman, 1893 ; Perrier, 1894 ; Apellöf, 1896 ; Nicols, 1903 ; Koehler, 1909*a* ; Farran, 1913.)					
	costata Verrill . .	Verrill, 1885	..	..	American coast	1623–3693 m.	..
	hirsuta Perrier . .	Perrier, 1894	1	1	Off Norway	2030 m.	
Pacific .	*tenella* Ludwig . .	Ludwig, 1905	10	1	Galapagos Is.	2418 m.	Globigerina ooze.
	panamensis Ludwig .	,, ,,	28	6	Gulf of Panama, Gulf of California, Galapagos Is.	1820–2418 m.	Green mud ; sand ; rocks ; globigerina ooze.
		Clark, 1913	6	3	Off California	1586–1911 m.	..
	exilis Fisher . .	Fisher, 1904	..	1	,,	1133 m.	Green mud ; rocks.
Eastern Archipelago	*trachydisca* Fisher .	,, 1916	12	6	Philippines	1100–1400 m.	Green mud ; sand ; coral.
Indian .	*insularum* Alcock & Wood-Mason	Alcock and Wood-Mason, 1891	..	..	Laccadive Sea	1900 m.	Green mud and foraminifera.
	bengalensis Alcock & Wood-Mason	Ditto	..	..	Bay of Bengal	1000 m.	Grey mud.
	andamanica Alcock & Wood-Mason	,,	..	..	Andaman Sea	750 m.	Green mud.
	gunnii Alcock . .	Alcock, 1893	..	..	Konkan coast	1020 m.	Green sand.

* In his text Koehler gives this figure as one of the illustrations of *O. austini*, but on the plate it is labelled *O. clarki*.

Brisinga trachydisca Fisher.

Brisinga trachydisca, Fisher, 1916, p. 31 ; 1919, p. 510, pl. 145, pl. 149, fig. 5, pl. 152, figs. 1 *a–c*, pl. 156, figs. 1, 1*a*.

Occurrence :

St. 108, Zanzibar area, 786 m., grey mud ; 3 disks and arms.

St. 115, „ „ 640–658 m. ; 6 disks and arms.

St. 124, „ „ 914 m. ; arms only.

Distribution.—Philippines, 1100–1400 m. ; Zanzibar area.

Remarks.—Of the nine disks, four have thirteen and five fourteen arms. Fisher gives the number of arms as twelve or thirteen. In other respects the specimens agree with Fisher's description.

Brisinga gunnii Alcock.

Brisinga gunnii, Alcock, 1893, p. 120.

Occurrence :

St. 34, Gulf of Aden, 1022 m., green mud ; arms only.

Distribution.—Konkan coast, India, 1020 m. ; Gulf of Aden.

Remarks.—The arms are similar to those taken in the neighbourhood of Zanzibar, but the costæ are fewer (about thirty) and they tend to form " hoops " at the side of the ray. Both these features are characteristic of *B. gunnii* which is closely related to *B. trachydisca*.

Genus *Freyellaster* Fisher.

Freyellaster spatulifer Fisher.

Freyellaster spatulifer, Fisher, 1916, p. 34 ; 1918, p. 104 ; 1919, p. 538, pl. 144, fig. 1, pl. 154, fig. 3, pl. 155, figs. 1, 1*a–h*.

Occurrence :

St. 118, Zanzibar area, 1789 m., globigerina ooze ; 2 specimens.

Distribution.—Celebes ; Zanzibar area.

RELATIONSHIPS OF THE FAUNA OF THE WESTERN INDIAN OCEAN

A chart showing the track of H.E.M.S. "Mabahiss" is given at the end of Vol. I No. 1, and the stations where Asteroids were taken are listed below. Investigations in the Bay of Bengal and the Arabian Sea have been carried out in past years by the R.I.M.S. "Investigator". H.M.S. "Sealark" had dredged around the Maldives and Seychelles, and the passage of the "Valdivia" took her to Zanzibar and thence north along the African coast: unfortunately the report on the "Sealark" collections is too unsound to be considered, and that of the "Valdivia" has, at the time of writing, extended only to the family *Porcellanasteridæ*.

This discussion, therefore, is based on the present report and the reports on the "Investigator" material by Alcock (1893) and Koehler (1909). Koehler's list, emended by the removal of two new and one previously described species of *Nymphaster*, contains thirty-six species, of which twenty-eight are new. Alcock's list, emended by Koehler and further altered by the removal of *Dytaster anacanthus* Alcock & Wood-Mason, has forty-eight species, of which forty are new. The deep-water species obtained by the John Murray Expedition number forty, of which thirteen species and two sub-species are new, ten are due to Alcock or Koehler, and fifteen are due to other authors and are, therefore, new to the region. The total number of species known to occur in the Western Indian Ocean is thus one hundred and fourteen. With our present knowledge it is possible to compare not only the faunas of the different areas within the region of the Indian Ocean with each other. but also the fauna as a whole with that of the regions which adjoin. To the south, the region around the Cape of Good Hope has been thoroughly worked by the vessels of the Union of South Africa Fisheries and Marine Biological Survey, whose catches have been reported on by H. L. Clark (1923, 1925) and Mortensen (1933). The Antarctic Asteroidea are known from the researches of the "Scotia" and the "National Expedition Antarctique Française". The Eastern Archipelago is a region whose starfish fauna has received more attention than that of most: the "Albatross" and "Siboga" have made large collections, and many of the earlier expeditions brought home material from this part of the world. Further east the Pacific fauna is little known until the American coast, where the "Albatross" has done much collecting, is reached, and the only substantial contribution to our knowledge of the Asteroids of the Mid-Pacific is derived from the visit of the "Albatross" to the Hawaiian Islands in 1903.

In order that comparison may be made the region covered by the "Investigator" and the "Mabahiss" is here divided into seven areas. To the first three arbitrary boundaries have been assigned:

i. *Bay of Bengal:*

In this area I have included the region to the East of the Andaman and Nicobar Islands that has been termed the Andaman Sea. This area is bounded by the parallel of 5° N.

ii. *Arabian Sea :*

This area, in which I include the Gulf of Oman, is separated from the Gulf of Aden area by a line joining Cape Gardafui and Ras Fartak, and is bounded to the south by a line between Cape Gardafui and the south-west corner of the Gulf of Manaar area (Stas. 43, 45, 53, 59, 70, 72).

iii. *Gulf of Manaar :*

The boundaries of this small intermediate area are the parallels 5° N. and 10° N. and the meridians 78° E. and 80° E.

The limits of the next three areas are defined only by the positions in which "Mabahiss" worked successful biological stations.

iv. *Maldive Archipelago :*

Stations were located only between the atolls and within an area extending a few miles on either side (Stas. 143, 145, 146, 152, 153, 157, 159).

v. *Zanzibar area :*

All successful biological stations were within a radius of twenty miles from the Island (Stas. 104 to 110, 115, 116, 118, 120, 122, 123, 124).

vi. *African coast :*

This area has but a single station (171) on the south-west slope of the Carlsberg ridge.

vii. *Gulf of Aden :*

This area is separated from the Red Sea by the Straits of Bab-el-Mandeb and from the Arabian Sea by a line joining Cape Gardafui and Ras Fartak (Stas. 22, 24, 26, 27, 34, 35, 184, 185, 194).

For each area I have given below a list of the known species. "Investigator" records have been taken from Koehler's paper (1909, pp. 129–137), in which he gives both an account of the species described or recorded by him and a revised list of those recorded by Alcock. Accompanying each species I give the following data :

(i) Other areas or regions from which it is recorded. When the record is not due to the author of the species, the recorder's name or an abbreviation is given in brackets. The following abbreviations are used : A. = Alcock, A. & W.M. = Alcock and Wood-Mason, J.M. = John Murray Expedition, K. = Koehler.

(ii) Closely related species, and—

(iii) The distribution of these closely related species.

Two species have not been considered to be closely related unless the author of one of the species has definitely mentioned such a relationship. The apparent affinities of a fauna assessed by this means must be regarded with caution, for the determination of what constitutes close relationship is open to great personal variation: Fisher, for instance, considers two species to be related more readily than either Alcock or Koehler, and as a result there is, perhaps, in the following lists an undue emphasis on relationship with species occurring in the Eastern Archipelago.

Bay of Bengal:

"Mabahiss" did not visit this area and all the records are from the reports of Alcock and Koehler. Most of the specimens listed by the latter occurred east of longitude 90°. Alcock does not give exact positions, but records his specimens either from the "Bay of Bengal" or the "Andaman Sea". Most of the species occurring in depths of less than 2000 metres are from the latter area; whereas, with but few exceptions, those from depths greater than 2000 metres are from the former.

0–500 metres. 0–273 fathoms.

Species.	Other localities.	Related species.	Localities.
Dipsacaster pentagonalis A.	..	..	..
Calliaster mammillifer A.	..	..	..
Fromia andamanensis K.	..	..	..
Palmipes pellucidus A. (= ? yg. *ludovicus* K.)	..	..	..
Dictyaster xenophilus A. & W.M.	..	..	..
Persephonaster cœlochiles A.	..	*P. euryactis* F. *P. misakiensis* Goto	Eastern Archipelago. Japan.
Mediaster florifer (A.)	..	? *Rosaster cassidatus* sp. n.	Maldives.
Lithosoma pentaphylla (A.)	..	*L. actinometra* F.	Eastern Archipelago.
Anthenoides sarissa (A.)	..	*A. cristatus* (Sladen)	,, ,, Gulf of Aden (J.M.).
Zoroaster carinatus A.	..	*Z. c. philippensis* F. *Z. adami* K.	Eastern Archipelago. Arabian Sea.
Ceramaster arcuatus (Sladen)	Japan	..	..
Miltelipháster wood-masoni A.	Maldives (J.M.)	..	..
Dipsacaster sladeni A.	Cape of Good Hope (H. L. Clark)	..	..
Paranepanthia brachiata (K.)	Arabian Sea (J.M.), Gulf of Aden (J.M.)	*P. joubini* (K.)	Eastern Archipelago.
Sclerasterias mazophorus (A. & W.M.)	,, ,, ,,	*S. euplecta* (F.) *S. hypacantha* (F.) *S. stenactis* (H. L. Clark)	Hawaii. Eastern Archipelago. Natal.

500–1000 metres. 273–546 fathoms.

Species.	Other localities.	Related species.	Localities.
Zoroaster gilesii A.	..	..	..
Nymphaster nora A.	..	*N. mœbii* (Studer)	Eastern Archipelago.
Henricia mutans (K.)	..	*H. præstans* (Sladen)	Southern Ocean.
Brisinga andamanica A. & W.M.	..	*B. trachydisca* F.	Eastern Archipelago.
		B. insularum A. & W.M.	Arabian Sea.
Astropecten griegi K.	Arabian Sea, Maldives (J.M.)	..	..
Pseudarchaster mozaicus A. & W.M.	Arabian Sea (K.), Gulf of Manaar (K.), Zanzibar (J.M.)	*P. jordani* F.	Hawaii, Eastern Archipelago, Gulf of Manaar (K), Arabian Sea (K.).

1000–2000 metres. 546–1093 fathoms.

Brisinga gracilis K.	..	..	..
B. bengalensis A. & W.M.	..	*B. insularum* A. & W.M.	Arabian Sea.
Zoroaster adami K.	..	*Z. carinatus* A.	Bay of Bengal.
Eugoniaster investigatoris (A.)	..	*E. döderleini* (K.)	Arabian Sea.
		E. ephemeralis sp. n.	Zanzibar.
Pentagonaster mortenseni K.	..	*Ceramaster arcticus* Verrill	Bering Sea.
Psilaster agassizii (K.)	..	*P. gotoi* F.	Eastern Archipelago.
Nymphaster mœbii (Studer)	Eastern Archipelago all areas (see p. 374)	*N. euryplax* F.	Eastern Archipelago.
Sidonaster batheri K.	Arabian Sea, Gulf of Manaar	*S. vaneyi* F.	,, ,, Arabian Sea (K.).
H. alcocki K.	Zanzibar (J.M.)	..	..
Cheiraster snyderi F.	Hawaii	..	..

2000–3000 metres. 1093–1640 fathoms.

Freyella indica K.	..	..	..
Porcellanaster caulifer Sladen	Eastern Archipelago, Arabian Sea (K.), Gulf of Manaar (K.), Cape of Good Hope (H. L. Clark)	..	..
Zoroaster alfredi A.	Arabian Sea (J.M.)	*Z. ophiactis* F.	Eastern Archipelago.
Z. barathri A.	..	*Z. microporus* F.	,, ,,
Benthopecten huddlestonii (A.)	..	*B. moluccanus* F.	,, ,,

3000–4000 metres. 1640–2187 fathoms.

Caulaster dubius K.	..	..	..
Paragonaster tenuiradiis A.	..	..	..
Styracaster clavipes A. & W.M.	..	..	..
Hymenaster nobilis Wyville Thompson	S. Australia	*H. rhodopeplus* F.	Eastern Archipelago.
		H. koehleri F.	North Pacific.
Hyphalaster tara A. & W.M.	African coast (J.M.)	..	..

3000–4000 metres. 1640–2187 fathoms—*cont.*

Species.	Other localities.	Related species.	Localities.
Styracaster caroli Ludwig	Zanzibar	..	..
S. armatus Sladen	Eastern Archipelago	..	..
Pararchaster semisquamatus Sladen	Japan	..	..
Dytaster exilis Sladen	Pacific coast of South America	..	..
Persephonaster gracilis (Sladen)	Japan, Arabian Sea (J.M.), African coast (J.M.), Zanzibar (J.M.)	..	..
Marsipaster hirsutus Sladen	South Pacific	..	..
Freyella benthophila Sladen	,, ,,	..	..
F. tuberculata Sladen	Equatorial Atlantic	..	..

There are forty-nine species in the above list and of these no less than eleven are peculiar to the area, being as yet unknown from any other region, and, furthermore, they have no known close relative: the genus *Dictyaster*, with two species, one of them littoral, is confined to the area, and the genus *Milteliphaster*, with one species, is known besides only from the Maldives. Fifteen other species are also unknown outside the area but four of these have near relatives in other areas of the Indian Ocean, while the remaining eleven have near relatives in other oceans: of these latter no less than nine occur in the Eastern Archipelago, and one extends as far north as Japan and another is found in the Bering Sea, while one occurs in the Southern Ocean.

Of the remaining twenty-three species five are known from other areas of the Indian Ocean and have close relatives either in the Indian Ocean itself (one species) or in other oceans (five species), and a further five are without any close relative. Finally, thirteen species are known to occur in other oceans. Of these latter three are found in the Eastern Archipelago (one occurring also at the Cape of Good Hope), three are from as far north in the Pacific as Japan, one is from Hawaii, three from the South Pacific, one from South Australia, one from the Cape of Good Hope and one from the Equatorial region of the Atlantic Ocean. It is interesting to note that no less than eight of these thirteen species have been recorded only from the greatest depths of the Bay of Bengal.

The Arabian Sea:

The stations worked by "Mabahiss" extend up the coast of Arabia to the Gulf of Oman. The "Investigator" also dredged in the Gulf of Oman, but her main collections are from farther south in the Laccadive Sea.

The "Mabahiss" collections are small, as the east coast of Arabia is barren over large areas. The slopes are steep and rocky and a large patch south of Ras el Hadd smelt strongly of sulphuretted hydrogen. The following species were taken:

0–100 metres. 0–54 fathoms.

Astropecten monacanthus Sladen, *Stellaster equestris* (Retzius), *Stellasteropsis colubrinus* sp. n., *S. tuberculiferus* sp. n., *Oreaster hiulcus* Müller and Troschel, *Nardoa faouzii* sp. n., *Paranepanthia brachiata* (Koehler), *Acanthaster mauritiensis* de Loriol.

Species.	Other localities.	Related species.	Localities.
2000–3000 metres. 1093–1640 fathoms.			
Pseudarchaster diversigranulatus sp. n.	Gulf of Aden	*P. mozaicus* A. & W.M. .	Arabian Sea (K.), Bay of Bengal, Gulf of Manaar (K.), Zanzibar (J.M.).
3000–4000 metres. 1640–2187 fathoms.			
Zoroaster alfredi A. . . .	Bay of Bengal	*Z. ophiactis* F. . .	Eastern Archipelago.
Persephonaster gracilis (Sladen)	Japan, Bay of Bengal (A.), African coast (J.M.), Zanzibar (J.M.)	..	..

The following species were collected by the "Investigator":

500–1000 metres. 273–546 fathoms.			
Astroceramus fisheri K. . .	..	..	..
Astropecten griegi K. . . .	Bay of Bengal, Maldives (J.M.)	..	..
Mediaster ornatus F. . . .	Hawaii, Eastern Archipelago, Maldives (J.M.)	..	..
Pseudarchaster mozaicus A. & W. M.	Bay of Bengal, Gulf of Manaar (K.), Zanzibar (J.M.).	*P. jordani* F. . .	Hawaii, Eastern Archipelago, Gulf of Manaar (K.).
1000–2000 metres. 546–1093 fathoms.			
Johannaster superbus K. . .	..	..	..
Circeaster marcelli K. . .	..	..	..
C. magdalenæ K. . . .	..	..	..
Mediaster roseus (A.) . .	..	..	..
Pentagonaster cuenoti K. . .	Gulf of Manaar	..	..
Brisinga insularum A. & W.M.	..	*B. andamanica* A. & W.M.	Bay of Bengal.
Sidonaster batheri K. . .	Bay of Bengal, Gulf of Manaar	*S. vaneyi* K. . .	See below.
S. vaneyi K.	Eastern Archipelago (F.)	*S. batheri* K. . . .	See above.
Pectinaster hispidus (A. & W.M.)	Gulf of Manaar (K.)	*P. mimicus* (Sladen) . *P. filholi* Perrier . .	Eastern Archipelago. Atlantic.
Pectinaster mimicus (Sladen) .	Eastern Archipelago	*P. hispidus* (A. & W.M.) . *P. filholi* Perrier . .	Arabian Sea, Gulf of Manaar (K.). Atlantic.
Pseudarchaster mozaicus A. & W. M.	Bay of Bengal, Gulf of Manaar (K.), Zanzibar (J.M.)	*P. jordani* F. . . .	See below.
P. jordani F.	Hawaii, Eastern Archipelago, Gulf of Manaar (K.)	*P. mozaicus* A. & W.M. .	See above.
Cnemidaster squameus (A.) .	Gulf of Aden (J.M.)	*C. wyvilli* F. . . .	Eastern Archipelago.
Brisinga gunnii A. . .	Gulf of Aden (J.M.)	*B. trachydisca* F. . .	,, ,,
Pontaster pilosus A. . .	Gulf of Manaar	..	..
Persephonaster rhodopeplus A. & W.M.	,, ,,	..	..
Zoroaster angulatus A. . .	,, ,, Maldives (J.M.)	..	..

2000–3000 metres. 1093–1640 fathoms.

Species.	Other localities.	Related species.	Localities.
Thoracaster alberti K.	..	..	..
Zoroaster planus A.	..	..	..
Pontaster cribrellum A.	..	*P. subtuberculatus* Sladen.	South Pacific.
Benthopecten violaceus (A.)	..	*B. styracius* F.	Eastern Archipelago.
		B. polyctenius F.	,, ,,
Pentagonaster pulvinus Sladen	..	*P. mirabilis* Perrier	Atlantic.
		P. misakiensis Goto	Japan.
Eugoniaster döderleini (K.)	..	*E. investigatoris* (A.)	Bay of Bengal.
		E. ephemeralis sp. n.	Zanzibar.
Nymphaster mœbii (Studer)	Eastern Archipelago (all areas, see p. 374)	*N. euryplax* F.	Eastern Archipelago.
Cnemidaster zea (A.)	Gulf of Manaar	*C. wyvilli* F.	,, ,,
Porcellanaster caulifer Sladen	Eastern Archipelago Bay of Bengal (K.), Gulf of Manaar (K.), Cape of Good Hope (H. L. Clark)	..	..

Disregarding the records from depths of less than 100 m., there are thirty-two species in the list. Twelve are confined to the area; two genera, *Johannaster* with one species and *Circeaster* with two, are not known from elsewhere.

Twenty species occur outside the Arabian Sea or have close relatives in other areas, and of sixteen of these, 50% of the total number of species, the distribution extends to, or relatives are found in, the Eastern Archipelago.

Of the species occurring in other areas of the Indian Ocean it is noteworthy that only seven, all widely distributed forms, have been recorded from the Bay of Bengal, while two others have a close relative in that area; five species extend only to the Gulf of Manaar and three to the Gulf of Aden.

Three species have Atlantic relatives, but all have relatives in the Eastern Archipelago as well. One species has a South Pacific relative.

The characteristics of the fauna of the Arabian Sea and the Bay of Bengal may be summarized together:

(i) In both between a quarter and a third of the total number of species have not been found outside the area and are not closely related to any other known form. On the other hand, with few exceptions, these species belong to genera well known and widely distributed in other parts of the Indo-Pacific region.

(ii) The fauna of both shows a close affinity with that of the Eastern Archipelago.

(iii) The affinity of the two with this area is apparently closer than their affinity with each other.

(iv) In both a small number of species, nearly all occurring at the greatest depths, are known also from, or have relatives in, the South Pacific, the Southern or the Atlantic Ocean.

Gulf of Manaar :

Off the west coast of Ceylon there is a deep gulley, lined with blue clay—an unusual bottom deposit in the Indian Ocean. The "Investigator" has dredged a remarkable collection of species from this area, and it is, therefore, now treated separately :

Species.	Other localities.	Related species.	Localities.
	500–1000 metres. 273–546 fathoms.		
Lydiaster johannæ K.	..	..	..
Benthopecten indicus (K.)	..	..	..
Cheiraster inops F.	Hawaii, Eastern Archipelago	..	..
Evoplosoma augusti K.	..	*E. forcipifera* F.	Hawaii.
Odinia austini K.	Maldives (J.M.)	*O. clarki* K.	Maldives.
P. mozaicus A. & W.M.	Arabian Sea, Bay of Bengal, Zanzibar (J.M.)	*P. jordani* F.	See below.
	1000–2000 metres. 546–1093 fathoms.		
Zoroaster angulatus A.	Arabian Sea, Maldives (J.M.)	..	..
Pontaster pilosus A.	Arabian Sea	..	..
Pentagonaster cuenoti K.	Arabian Sea	..	..
Persephonaster rhodopeplus A. & W.M.	" "	..	..
Pectinaster hispidus (A. & W.M.)	" "	*P. mimicus* (Sladen) *P. filholi* Perrier	Eastern Archipelago. Atlantic.
Sidonaster batheri K.	" " Bay of Bengal	*S. vaneyi* K.	Arabian Sea. Eastern Archipelago (F.).
Pseudarchaster jordani F.	Hawaii, Eastern Archipelago, Arabian Sea (K.)	*P. mozaicus* A. & W.M.	See above.
Nymphaster mœbii (Studer)	Eastern Archipelago (all areas, see p. 374)	*N. euryplax* F.	Eastern Archipelago.
Cnemidaster zea (A.)	Arabian Sea	*C. wyvilli* F.	" "
Hymenaster pentagonalis F.	Hawaii	..	..
Brisinga panopla F.	"	*B. parallela* K.	Gulf of Manaar.
B. parallela K.	..	*B. panopla* F.	Hawaii.
Persephonaster croceus A.&W.M.	..	*P. monostœchus* F.	Eastern Archipelago.
Pentagonaster annandalei K.	..	*P. micropelta* F.	Hawaii.
	2000–3000 metres. 1093-1640 fathoms.		
Porcellanaster caulifer Sladen	Eastern Archipelago, Arabian Sea (K.), Bay of Bengal (K.), Cape of Good Hope (H. L. Clark)	..	..

Of the twenty-one species in this list, there are only two which neither occur nor have a relative elsewhere. One is the only known member of its genus (*Lydiaster*).

Four of the seven species common to the Bay of Bengal and the Arabian Sea are recorded in this area. Five species occur both here and in the Arabian Sea, but there are no species whose known distribution embraces this area and the Bay of Bengal only.

The main interest lies in the close affinity with the Hawaiian Islands. *Hymenaster pentagonalis* and *Brisinga panopla* are known only from these islands and the area under discussion; *Cheiraster inops* and *Pseudarchaster jordani* have a similar distribution but have been found in the Eastern Archipelago as well. Three species (*Brisinga parallela*, *Evoplosoma augusti* and *Pentagonaster annandalei*) are closely related to Hawaiian species. and *Pseudarchaster mozaicum* is very close to *P. jordani*, also from Hawaii.

The Maldive Archipelago:

This area was visited in 1906 by the Percy Sladen Trust Expedition, but many of the starfish collected have been inaccurately named, and the following list includes only those taken by "Mabahiss":

Species.	Other localities.	Related species.	Localities.
	0–50 metres. 0–27 fathoms.		
Astropecten polyacanthus Müller & Troschel	Widely distributed	..	..
	50–500 metres. 27–273 fathoms.		
Dipsacaster farquharsoni sp. n.	..	..	..
Astroceramus cadessus sp. n.	..	..	..
Narcissia mohamedi sp. n.	Gulf of Aden	..	..
Astropecten griegi K.	Bay of Bengal, Arabian Sea	..	..
Milteliphaster wood-masoni A.	Bay of Bengal	..	..
Ophidiaster purpureus Perrier	Widely distributed	..	..
Rosaster cassidatus sp. n.	..	? *Mediaster florifer* (A.)	Bay of Bengal.
Astropecten pusillulus F.	Hawaii	*A. eremicus* F.	Eastern Archipelago.
Paragonaster ctenipes brevi-radiatus subsp. n.	Zanzibar	*P. ctenipes* Sladen	,, ,,
Pteraster obesus H. L. Clark	Japan, Gulf of Aden (J.M.)	*P. obesus myonotus* F.	,, ,,
	500–1000 metres. 273–546 fathoms.		
Nymphaster mœbii (Studer)	Eastern Archipelago (all areas, see p. 374)	*N. euryplax* F.	Eastern Archipelago.
Odinia austini K.	Gulf of Manaar	*O. clarki* K.	Maldives.
	1000–2000 metres. 546–1094 fathoms.		
Mediaster ornatus F.	Hawaii, Eastern Archipelago, Arabian Sea (K.)	..	..
Zoroaster angulatus A.	Gulf of Manaar, Arabian Sea	..	..

Other localities or relatives are unknown for only two species. The remaining thirteen show that the area has close affinities with those lying to the north and east of it.

Zanzibar area :

Dredging in the deep water round Zanzibar had previously been done only by the " Valdivia ". The report on the starfish collected by this vessel has, at the time of writing, only covered the family *Porcellanasteridæ.* In it there are two records :

" *Styracaster caroli* Ludwig, 2959 metres, recorded also from the Bay of Bengal by Koehler."
" *Pcctinidiscus annæ* Ludwig, 400–463 metres, related to *P. sibogæ* Döderlein from the Eastern Archipelago."

The following species were collected by " Mabahiss " :

Species.	Other localities.	Related species.	Localities.
	50–500 metres. 27–273 fathoms.		
Mabahissaster zengi gen. et sp. n.	..	..	..
Mediaster murrayi sp. n. .	..	..	..
Lithosoma ochlerotatus sp. n. .	..	*L. actinometra* F. .	Eastern Archipelago.
		L. penichra F. .	,, ,,
		L. pentaphylla (A.) .	Bay of Bengal.
Pectinidiscus annæ Ludwig .	..	*P. sibogæ* Döderlein	Eastern Archipelago.
Persephonaster sewelli sp. n. .	..	*P. habrogenys* F. .	,, ,,
		P. œdiplax F. .	
Paragonaster stenostichus F. .	Eastern Archipelago	..	..
P. ctenipes breviradiatus subsp. n.	Maldives	*P. ctenipes* Sladen .	Eastern Archipelago.
Nymphaster mœbii (Studer) .	Eastern Archipelago (all areas, see p. 374)	*N. euryplax* F. .	,, ,,
Anthenoides marleyi Mortensen	Natal	*A. piercei* Perrier .	Atlantic.
	500–1000 metres. 273–546 fathoms.		
Eugoniaster ephemeralis sp. n. .	..	*E. investigatoris* (A.)	Bay of Bengal.
		E. döderleini (K.) .	Arabian Sea.
Pseudarchaster mozaicus A. & W.M.	Bay of Bengal, Arabian Sea (K.), Gulf of Manaar (K.)	*P. jordani* F. .	Hawaii, Eastern Archipelago, Arabian Sea (K.), Gulf of Manaar (K.).
		P. diversigranulatus	Gulf of Aden.
Brisinga trachydisca F. .	Eastern Archipelago	*B. gunnii* A. .	Arabian Sea.
	1000–2000 metres. 546–1092 fathoms.		
Persephonaster cingulatus F. .	Hawaii, Gulf of Aden (J.M.)	*P. roulei* K. .	Unknown.
Hymenaster alcocki K. .	Bay of Bengal	..	..
Freyellaster spatulifer F. .	Eastern Archipelago	..	..
	2000–3000 metres. 1092–1640 fathoms.		
P. gracilis (Sladen) .	Japan, Bay of Bengal (A.), Arabian Sea (J.M.), African coast (J.M.)	..	..

Two of the seventeen species in this list, one the type of a new genus, are not known either to occur in or to have a relative in any other area. One species has a relative in the Atlantic.

All the remaining fourteen species extend to or have relatives in other areas of the Indo-Pacific region, and as in the case of the Bay of Bengal and the Arabian Sea, the affinity with areas lying to the eastward is closer than that with areas nearer at hand.

The pronounced Indo-Pacific character of the fauna is interesting since Zanzibar lies near the boundary of the zoo-geographical region. Thus the fauna at the Cape of Good Hope is quite different, and Clark (1923, 1925, see also Mortensen, 1933) records that out of thirty-nine species of Asteroid living below the littoral zone, twenty-three are endemic, and only three are Indo-Pacific forms. The boundary lies near 20° S. for, in Clark's words : "There are then only ten species (of Echinoderm) common to the South African coast and that of the Mozambique region. On the other hand of the fifty-nine species occurring at Mozambique fifty occur at Zanzibar or further northward and five others are known from some other part of the Indo-Pacific region."

African coast :

A single station, 171, lies in an enclosed basin on the south-west slope of the Carlsberg ridge at a depth of 3872 m. The following species were taken :

Species.	Other localities.	Related species.	Localities.
Eremicaster tenebrarius F.	North Pacific, American Coast	..	..
Hyphalaster tara A. & W.M.	Bay of Bengal	..	..
H. giganteus sp. n.	..	*H. parfaiti* Perrier	Atlantic.
		H. moseri Ludwig	Eastern Archipelago.
Persephonaster gracilis (Sladen)	Eastern Archipelago, Bay of Bengal (A.), Arabian Sea (J. M.) Zanzibar (J. M.)	..	..

Gulf of Aden :

The following species were collected by "Mabahiss" :

0–50 metres. 0–27 fathoms.

Astropecten polyacanthus Müller & Troschel, *Luidia avicularia* Fisher, *Stellasteropsis colubrinus* sp. n., *Narcissia mohamedi* sp. n.

50–500 metres. 27–273 fathoms.

Species.	Other localities.	Related species.	Localities.
Anthenoides cristatus (Sladen)	Eastern Archipelago	*A. sarissa* (A.)	Bay of Bengal.
Paranepanthia brachiata (K.)	Arabian Sea (J.M.) Bay of Bengal	*P. joubini* (K.)	Eastern Archipelago.
Pteraster obesus Clark	Eastern Archipelago, Maldives (J.M.)	*P. obesus myonotus* F.	,, ,,
Sclerasterias mazophorus (A.)	Bay of Bengal	*S. euplecta* (F.)	Hawaii.
		S. hypacantha (F.)	Eastern Archipelago.
		S. stenactis (H. L. Clark)	Natal.

1000–2000 metres. 546-1093 fathoms.

Species.	Other localities.	Related species.	Localities.
Persephonaster cingulatus (F.) .	Hawaii, Zanzibar (J.M.)	*P. roulei* (K.) . .	Unknown.
Pectinaster agassizii (Ludwig)	Gulf of Panama	*P. mimicus* (Sladen) .	Eastern Archipelago.
Pseudarchaster diversigranulatus, sp. n.	Arabian Sea	*P. mozaicus* A. & W.M. .	Bay of Bengal, Arabian Sea (K.), Gulf of Manaar (K.), Zanzibar (J.M.).
Pectinaster agassizii granuliferus subsp. n.	..	*P. agassizii* (Ludwig) .	Gulf of Panama.
Benthopecten heteracanthus sp. n.	..	*B. violaceus* (A.) . .	Arabian Sea.
Nymphaster mœbii (Studer) .	Eastern Archipelago (all areas, see p. 374)	*N. euryplax* F. . .	Eastern Archipelago.
Cnemidaster squameus (A.) .	Arabian Sea	*C. wyvilli* F. . . .	,, ,,
Brisinga gunnii (A.) . .	,, ,,	*B. trachydisca* F. . .	,, ,,

Eight of the twelve species in this list are known from, or have close relatives in, the Eastern Archipelago. Of the remainder one is known from Hawaii and another from the Pacific coast of America. The fauna also shows affinities with those of most of the neighbouring areas.

It is thus evident that the north-western region of the Indian Ocean is a part of a vast zoo-geographical area that extends far to the eastwards in tropical and sub-tropical waters; but a study of the various areas into which I have subdivided this region indicates that the fauna of some of these areas has a closer affinity with that of the Eastern Archipelago than with that of the others; but until all the species have been examined by one person this suggestion cannot be confirmed.

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DESCRIPTION OF PLATE I.

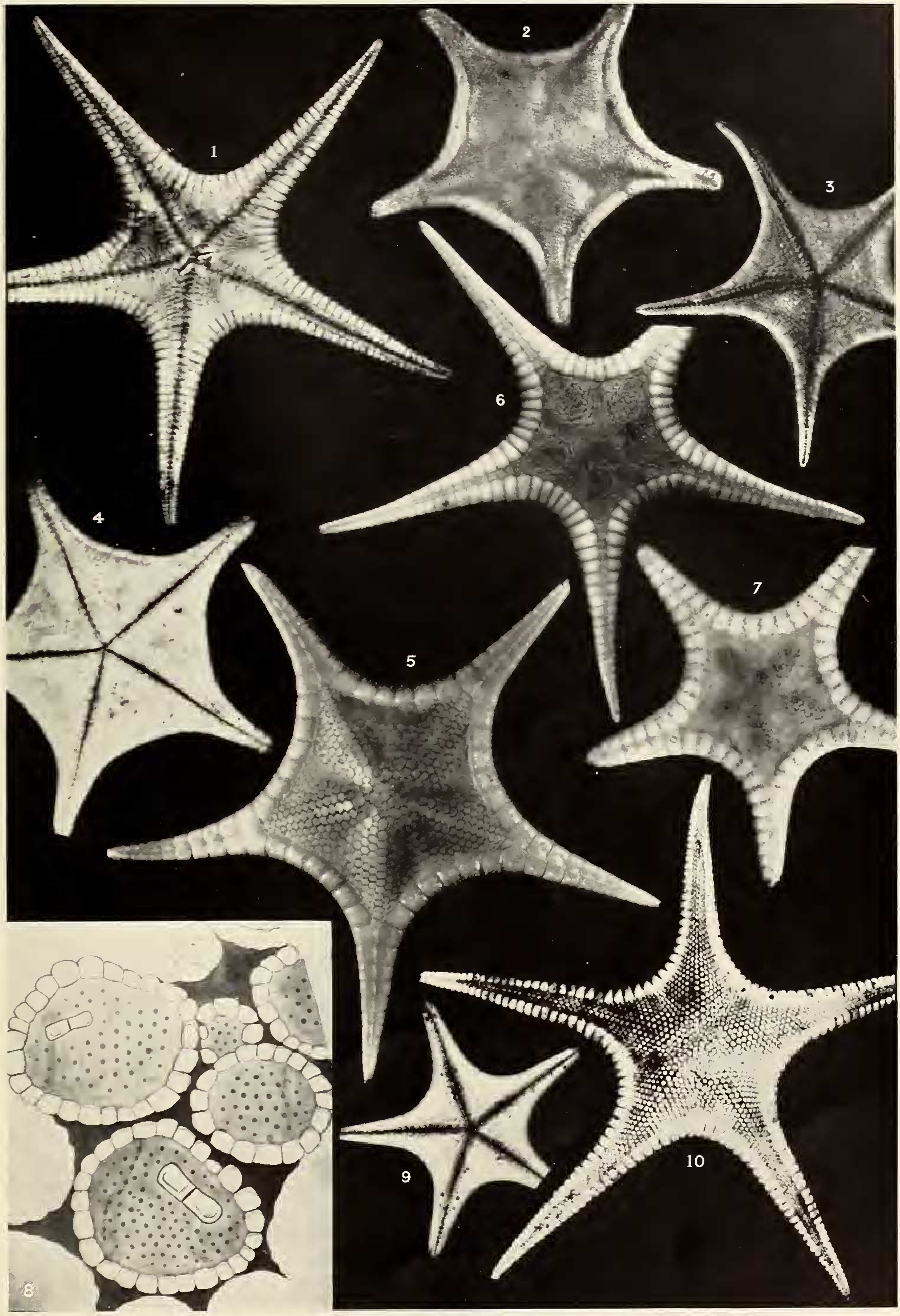
FIG. 1.—*Dipsacaster farquharsoni*. Actinal surface. $\times \frac{3}{4}$.
FIG. 2.—*Narcissia mohamedi*. Actinal surface. $\times \frac{3}{4}$.
FIG. 3.—*Hyphalaster giganteus*. Actinal surface. $\times \frac{3}{4}$.
FIG. 4.—*Dipsacaster farquharsoni*. Abactinal surface. $\times \frac{3}{4}$.
FIG. 5.—*Persephonaster sewelli*. Actinal surface. $\times \frac{3}{4}$.
FIG. 6.—*Persephonaster sewelli*. Abactinal surface. $\times \frac{3}{4}$.
FIG. 7.—*Hyphalaster giganteus*. Abactinal surface. $\times \frac{3}{4}$.
FIG. 8.—*Nardoa faouzii*. Abactinal surface. $\times$ 1.
FIG. 9.—*Nardoa faouzii*. Actinal surface. $\times \frac{3}{4}$.
FIG. 10.—*Narcissia mohamedi*. Abactinal surface. $\times$ 1.



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DESCRIPTION OF PLATE II.

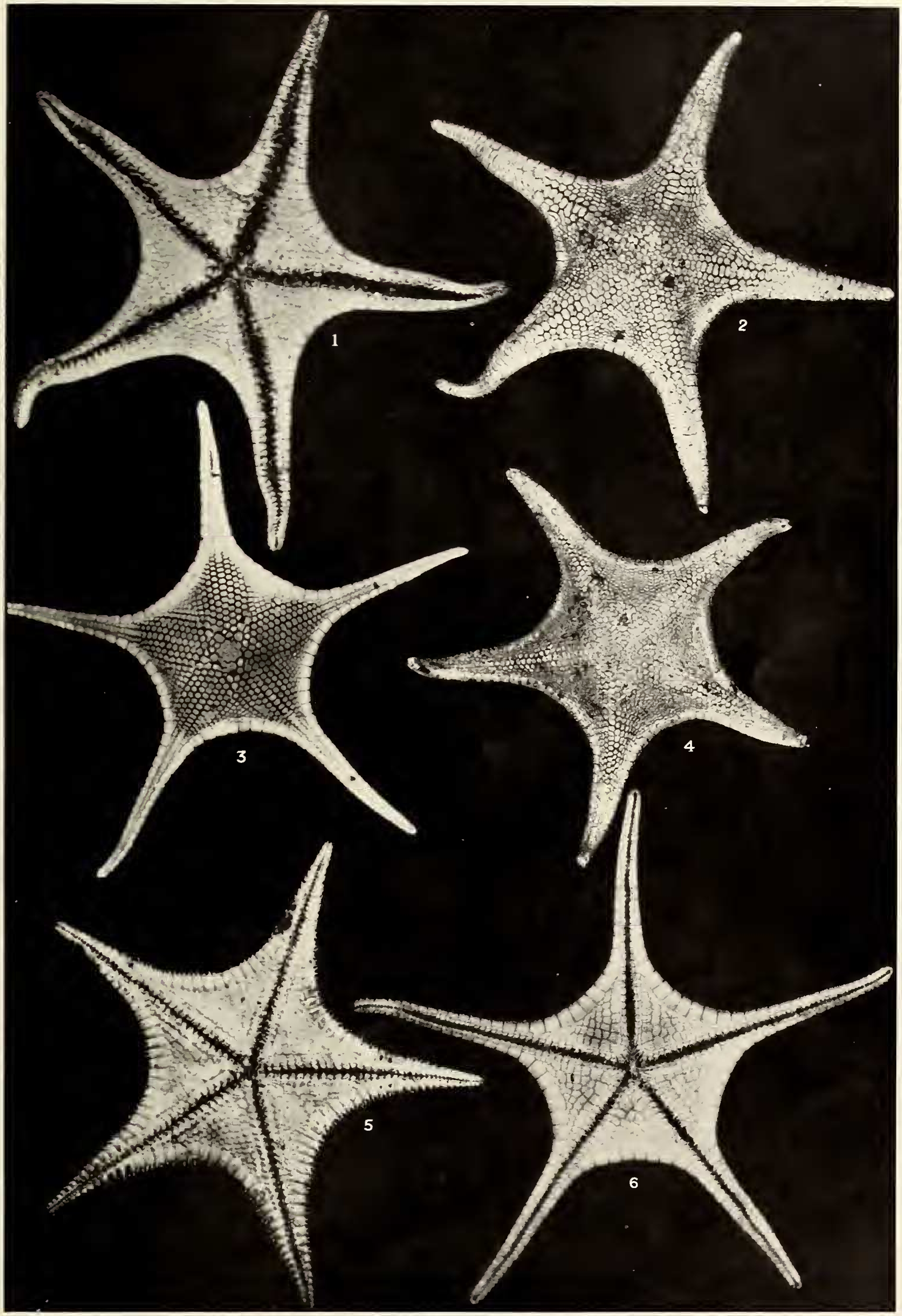
FIG. 1.—*Pseudarchaster mozaicus.* St. 122. Actinal surface. × $\frac{2}{3}$.
FIG. 2.—*Eugoniaster ephemeralis.* Abactinal surface. × $\frac{2}{3}$.
FIG. 3.—*Astroceramus cadessus.* Actinal surface. × $\frac{2}{3}$.
FIG. 4.—*Eugoniaster ephemeralis.* Actinal surface. × $\frac{2}{3}$.
FIG. 5.—*Astroceramus cadessus.* Abactinal surface. × 1.
FIG. 6.—*Paragonaster ctenipes breviradiata.* Abactinal surface. × 1.
FIG. 7.—*Lithosoma ochlerotatus.* Abactinal surface. × 1.
FIG. 8.—*Eugoniaster ephemeralis.* Radial abactinal plates. × 40.
FIG. 9.—*Lithosoma ochlerotatus.* Actinal surface. × $\frac{3}{4}$.
FIG. 10.—*Pseudarchaster mozaicus.* St. 122. Abactinal surface. × $\frac{2}{3}$.



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DESCRIPTION OF PLATE III.

Fig. 1.—*Mediaster murrayi*. St. 107. Actinal surface. × 1.
Fig. 2.—*Mediaster murrayi*. St. 109. Abactinal surface showing fusion of plates along ray. × 1.
Fig. 3.—*Rosaster cassidatus*. Abactinal surface. × 1.
Fig. 4.—*Mediaster murrayi*. Abactinal surface of normal specimen. × 1.
Fig. 5.—*Anthenoides cristatus*. St. 194. Actinal surface. × 1.
Fig. 6.—*Rosaster cassidatus*. Actinal surface. × 1.

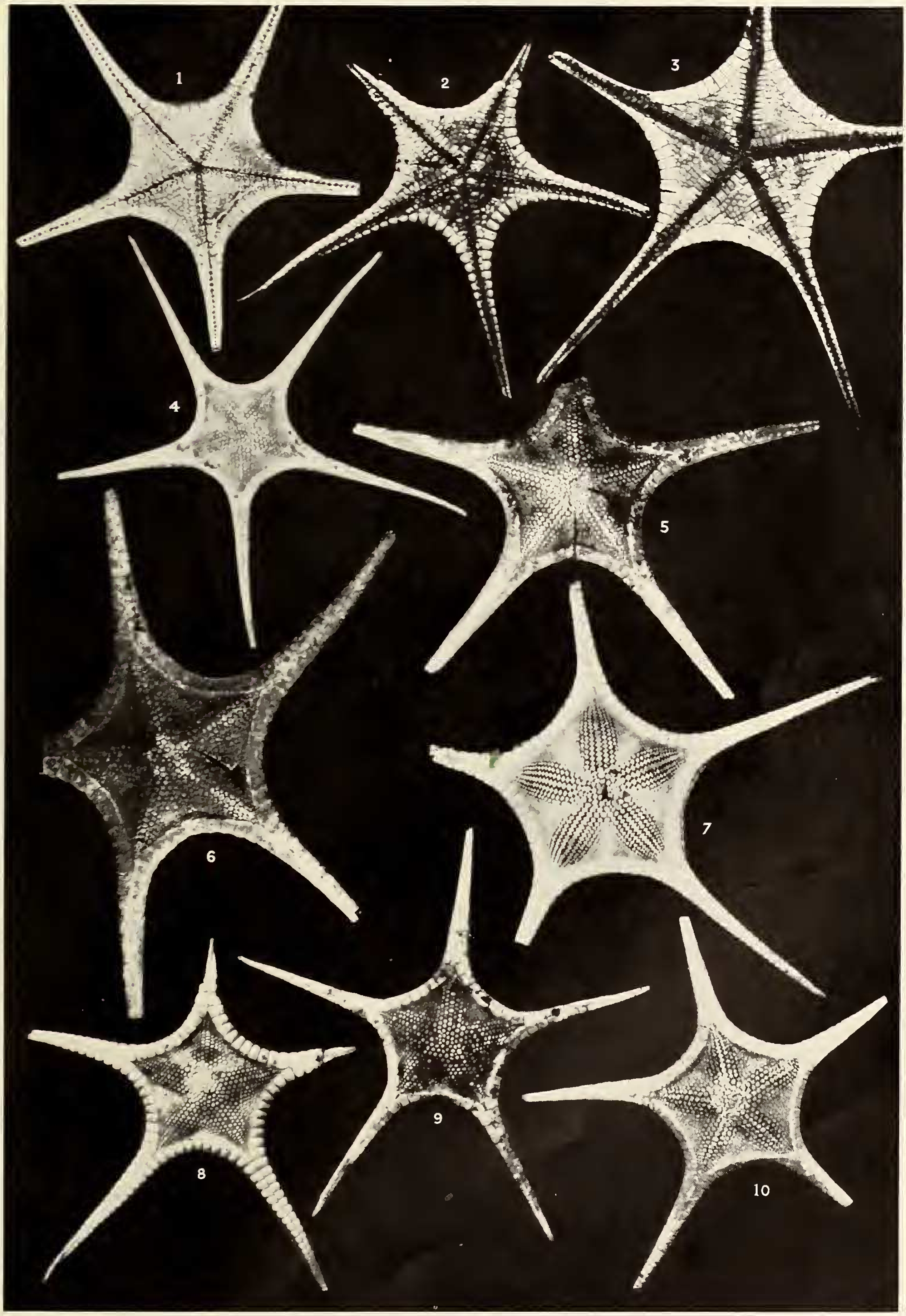


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DESCRIPTION OF PLATE IV.

Nymphaster mœbii. All figures $\times \frac{5}{8}$.

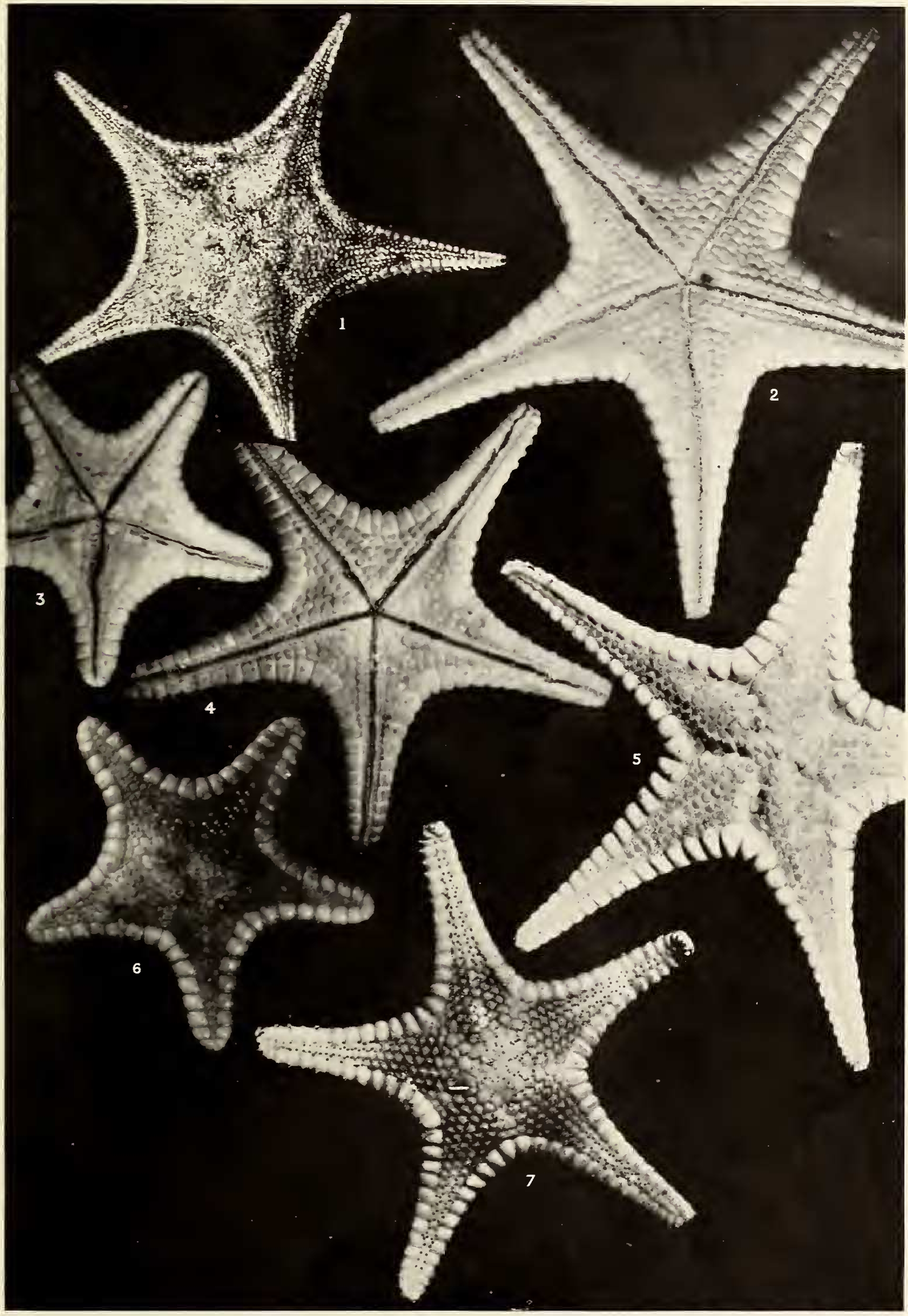
FIG. 1.—No. 98, 11. St. 122 (Zanzibar). Actinal surface.
FIG. 2.—No. 100*f*. St. 184 (Gulf of Aden). Actinal surface.
FIG. 3.—No. 96. St. 145 (Maldives). Actinal surface.
FIG. 4.—No. 17*c*. St. 105 (Zanzibar). Abactinal surface.
FIG. 5.—No. 98, 14. St. 122 (Zanzibar). Abactinal surface.
FIG. 6.—No. 98, 16. St. 122 (Zanzibar). Abactinal surface.
FIG. 7.—No. 96. St. 145 (Maldives). Abactinal surface.
FIG. 8.—No. 100*f*. St. 184 (Gulf of Aden). Abactinal surface.
FIG. 9.—No. 112*c*. St. 115 (Zanzibar). Abactinal surface.
FIG. 10.—No. 98, 11. St. 122 (Zanzibar). Abactinal surface.



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DESCRIPTION OF PLATE V.

Fig. 1.—*Anthenoides cristatus.* Abactinal surface. × 1.
Fig. 2.—*Stellasteropsis colubrinus.* St. 53. Actinal surface. × 1.
Fig. 3.—*Monachaster umbonatus.* Actinal surface. × 1.
Fig. 4.—*Stellasteropsis tuberculiferus.* Actinal surface. × 1.
Fig. 5.—*Stellasteropsis colubrinus.* Abactinal surface. × 1.
Fig. 6.—*Monachaster umbonatus.* Abactinal surface. × 1.
Fig. 7.—*Stellasteropsis tuberculiferus.* Abactinal surface. × 1.

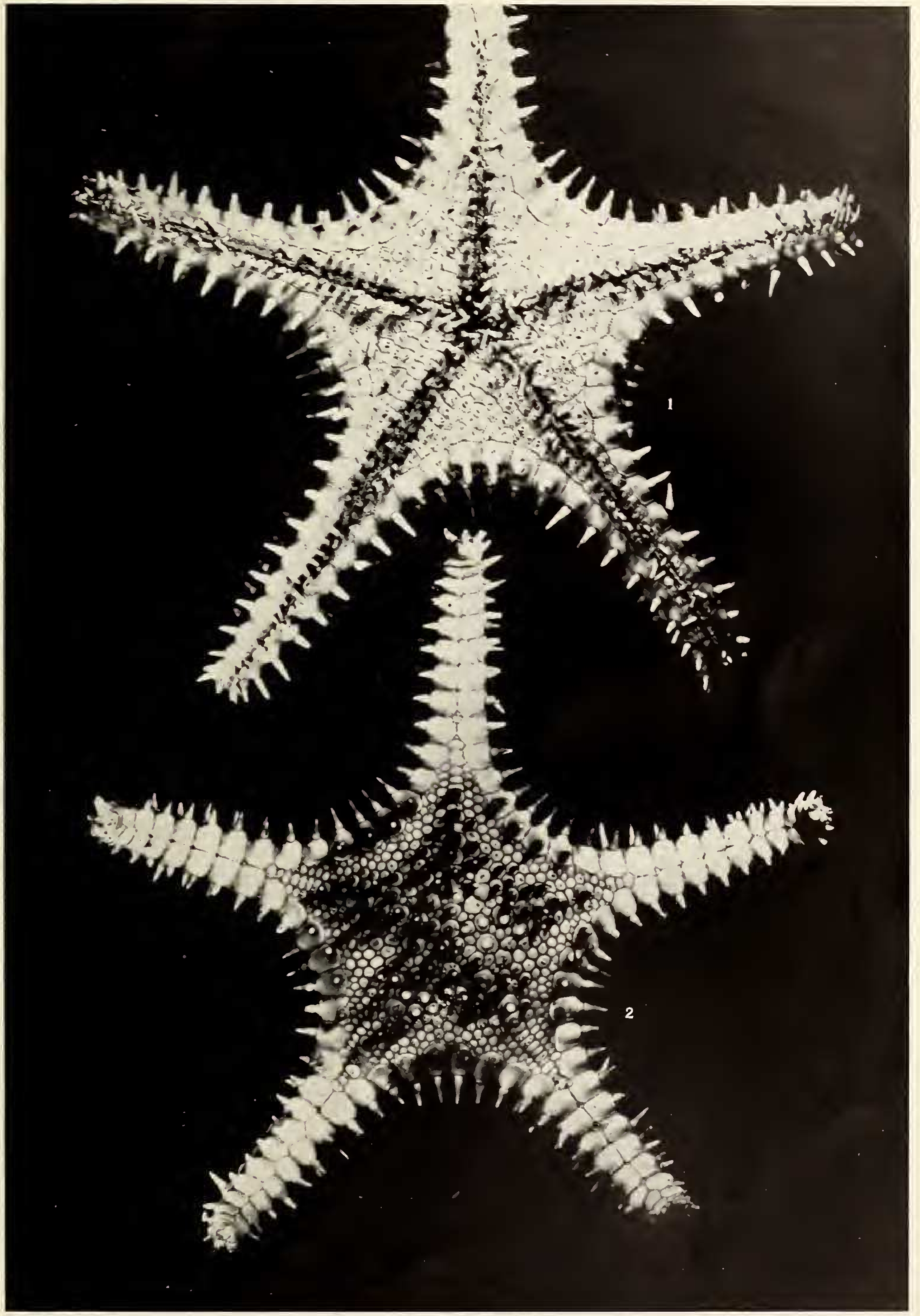


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DESCRIPTION OF PLATE VI.

Mabahissaster zengi. × 1.

FIG. 1.—Actinal surface.
FIG. 2.—Abactinal surface.



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